Cement MILL EDITION of

Concrete

Devoted to the Manufacture,
and Use, of Portland Cement

SEPTEMBER, 1935

400 West Madison Street
Chicago, Illinois

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FOR INFO

Billion Dollars for Roads

FEDERAL appropriation of highway funds may suffer a set-back when the 1936-1937 program is presented to the next session of Congress, unless Congress and the Administration can be shown that funds already available are being used.

◖ This very logical deduction has been brought forward by the American Road Builders' Association, which reminds highway commissions and engineers that they now have at their command a potential fund well in excess of a billion dollars for utilization within the next twelve months, if programs are properly and quickly presented.

◖ At the present moment the highway, street and grade-crossing elimination set-up stands:

(1) Federal aid (to be matched by states)	$125,000,000
(2) From states (if they match federal aid)	125,000,000
(3) Emergency relief funds for highways, secondary roads, and streets	200,000,000
(4) Emergency relief funds for grade-crossing elimination	200,000,000
Total	$650,000,000

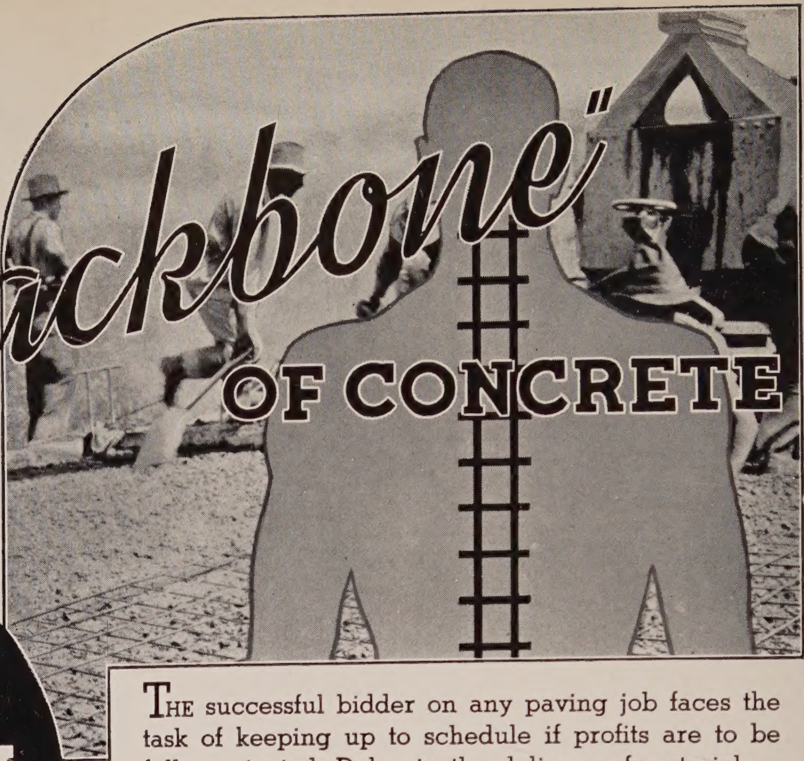
◖ Potential emergency relief funds for highways, streets, and grade-crossing eliminations, not yet allotted, amount to 300 million dollars; and available state funds in excess of requirements to match federal aid are estimated at 100 million.

◖ The last two items bring the total to $1,050,000,000; but these funds will not be dropped into the laps of highway commissions who prepare no programs.

◖ Rules governing the securing and expenditure of these funds are explained in a special report issued by the American Road Builders' Association.

◖ All branches of the highway construction industry should join with the A.R.B.A. in a united effort to get these potential funds utilized to the greatest extent.

BACK OF THIS "Backbone" OF CONCRETE



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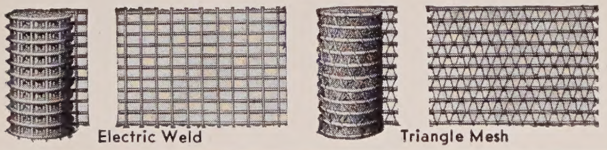

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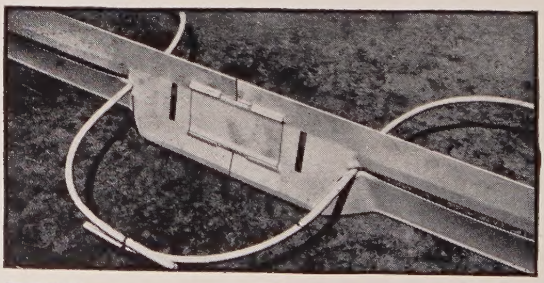

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Vol. XLIII, No. 9 Concrete September, 1935

Street Car Track Pavement Placed at Low Cost

Old Concrete Base Retained—Pre-mixed Batches from Central Proportioning Plant—Smooth Handling of Construction Work Brings Economy

THE street railway system of Columbus, Ohio, operated by the Columbus Railway, Power & Light Co., has started reconstruction of its track pavement in Livingston Ave. with a strip of concrete 13 ft. wide, extending from Kelton Ave. to Parsons Ave. The new pavement extends between the outside rails of the double track, and ranges from 4½ to 5 in. in thickness. The cost of the work was extremely low.

Old Concrete Base Remains

Wood paving block, set in a dry 1:3 cement-and-sand mortar, and supported on an old concrete base, comprised the old paving surface. The wooden blocks were ripped up with a truck-drawn plow, and then hauled away, and the 1:3 mortar bed was removed after being broken loose with a vibro-spade.

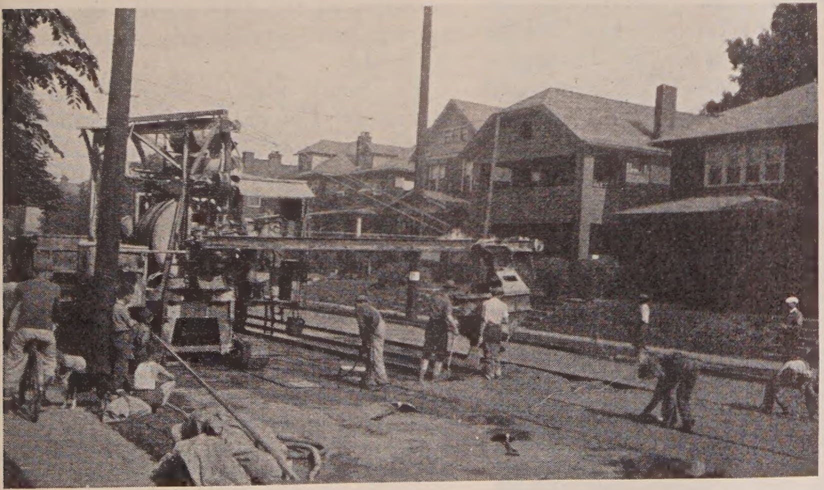
The old concrete base, placed 22 years ago, remains in place and is now serving as the base for the newly-placed concrete pavement. Another feature of the track base which remains in place for continued service is the concrete base-girder under each rail—a continuous base 18 in. wide, also placed 22 years ago. The 7-in. grooved rails (103-lb. weight) also remain in service, though they were coated with asphalt on both sides to prevent their bonding with the newly-placed concrete pavement. The old Carnegie steel ties, set at 4 ft. 6 in. centers, also remain in place. Tie rods of the strap type, placed 10 ft. apart in the old track structure, were cut out, except that every third rod is left in place. These remaining tie rods 30 ft. apart, serve as locations for expansion joints in the new concrete pavement.

Bond is prevented between the new concrete pavement and the old concrete base, and also between the new pavement and the rails, as previously stated.

Construction Features

Interesting features of the construction are seen in the fact that street car service continued without interruption during construction operations, and in the operation of the paving mixer, which moved on caterpillars along one side of the tracks and delivered its batches over the entire width of the pavement. The street-car service was interrupted only during the breaking up of the old wood block pavement.

Still another novel feature of the work was the delivery of dry pre-mixed batches of cement and aggregates in motor trucks provided with four compartments—one batch in each compartment. Each of these compartments carried a batch consisting of 2,800 lb. of aggregates mixed with 5 sacks of cement. The pre-mixed batches were hauled from a commercial central proportioning plant, and the original source of the gravel was a pit having an overburden from 6 to 12 ft. thick. The depth of the gravel ranges from 20 to 60 ft. This gravel is a mixed material containing some pieces of doubtful quality, and the clay, or silt, content is quite high. The state highway depart-



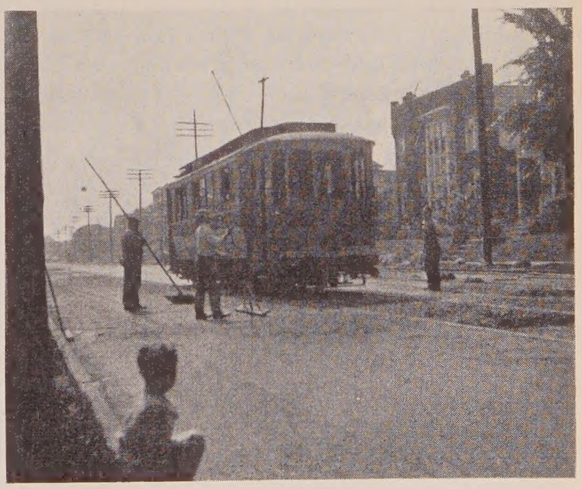


Fig. 1 (Left)—A paving mixer, mounted on caterpillars, operated along the side of the street car tracks.
Fig. 2 (Right)—Street car service was uninterrupted during construction of the new concrete pavement

ment, however, accepts this material for concrete highway construction.

Proportioning and Placing

Batches of concrete were proportioned as follows:

5 sacks of high-early-strength cement at 94 lb.	470 lb.
Water, 5.4 gallons to sack of cement	27 gallons
Aggregate—	
Sand	1,000 lb.
Gravel, ½-in.	550
Gravel, ¾-in.	650
Gravel, 1½-in.	600
Total aggregate	2,800 lb.

This mixture had a yield of 1 cu. yd., in place, for every 6.3 sacks.

With these proportions the mixtures had a good appearance and handled well, though some variation occurred in the slump, doubtless due to varying moisture contents in the sand and gravel. Each batch, when deposited by the mixer bucket, was shoveled and pushed to a roughly level surface, then worked with a screed board and wood floats. This was followed by further work with the wood floats, and edging tools were used along the rail heads and the expansion joints. Finally, the surface was dragged with burlap. The finished appearance is good.

Speed of Construction

A Koehring paving mixer No. 21-E, mounted on a caterpillar and provided with a loading skip, was used on this work, with a crew consisting of two men as shovelers and spreaders, one operating the rail screed, two hand finishers, and one handy man— a total crew of six men. Speed of placing was about 75 ft. per hour, or 600 ft. per day of 8 hours. Compaction of the concrete was not as thorough as might be desired, though the concrete is undoubtedly of good quality. High-frequency vibration would have helped.

Curing of the newly-placed pavement was accomplished by means of frequent sprinkling by a tank truck of the regular street sprinkler type.

One doubtful detail of this pavement may cause trouble later, from frost action. The rails, as stated, were coated with hot asphalt to prevent bonding with the concrete, thereby creating a joint at each edge of each rail. The old 1:3 mortar was not entirely cleared from the rails, the asphalt having been brushed over it. This increases the possibility that water may enter the joints alongside the rails; and in this event the concrete next to the rails may suffer damage from the powerful action of frost.

Acknowledgments — The work here described and illustrated was placed in June of this year, under the supervision of D. R. Horton, superintendent of roadway for the Columbus Railway, Power & Light Co. The contractor was Frank Patterson, of Columbus. The paving mixer was a Koehring No. 21-E. The high-early-strength cement employed was the brand known as "Tri-Cal," produced at the Superior (Ohio) plant of the Superior Cement Corporation.

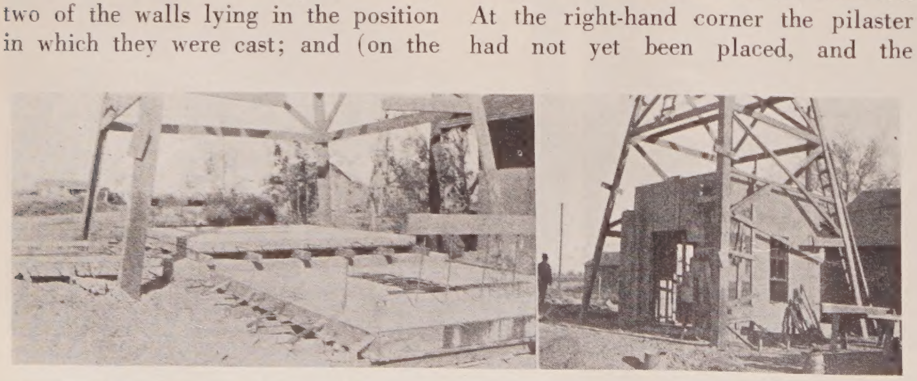
Precast Walls of Pump House Raised Into Position

Kansas Emergency Relief Project Handled by Unskilled Labor—Work Supervised by Engineer

ONE of the many projects built by relief labor under the authority of the Kansas Emergency Relief Commission was a precast concrete pump house built in Lakin, Kansas, as a part of the town's water supply improvements.

The pump house is a precast structure in the sense that the reinforced concrete walls were cast in a flat position alongside the concrete floor slab, and then raised into position after the concrete had hardened.

The illustrations show (on the left) two of the walls lying in the position in which they were cast; and (on the right) the completed pump house. Both pictures show the A-frame erected to provide a means for raising the wall slabs. After the walls were in position, the unfinished corners were concreted in place, the steel reinforcement in the walls having been placed so as to protrude from the slabs at the corners. These corners were concreted in the form of ornamental pilasters, two of which may be seen in the illustration of the pump house—at the left-hand corner and the one nearest the observer. At the right-hand corner the pilaster had not yet been placed, and the projecting reinforcing bars could still be seen, when the picture was taken.



At left: Concrete walls cast on ground, ready to be raised into position. At right: Walls erected and two corner pilasters cast in place

C. W. Suit, an engineer of Garden City, Kansas, designed the pump house and supervised its erection. Mr. Suit also supervised similar work in the construction of a bath house and swimming pool at Satanta, Kansas. This later was also a Kansas Emergency Relief project.

F. Leo Smith, chief architect of the technical division of the Federal Housing Administration, died July 21 at Washington. Mr. Smith, who had been ill for only a short time, was the first executive of the FHA to die since that agency was established. He was 42 years old.

Mr. Smith was an alternate on the Standards Council of the American Standards Association, which gives final approval to standards submitted to the ASA, representing the American Institute of Architects, from October 1931 to March 1932.

He was a native of Marion, Ohio. In 1924 he became associated with the Ohio Board of Building Standards, and the next year was made field engineer for the Portland Cement Association, continuing in that position until 1931. Since then he had served as technical secretary of the structural service division of the American Institute of Architects, holding that position at the time of his death.

Rented When Modernized

Cincinnati Bank Building, Vacant for Three Years, Transformed into Modernistic and Colorful Retail Business Building—Now Fully Occupied

THE reconstruction of the Fifth-Third National Bank Building, in Fourth Street, Cincinnati, is an unusual modernizing project, because in this case the problem was not one of transforming an old building into a new one. On the contrary, the problem was that of bringing about a complete change in the character of the building—from a severely cold and forbidding bank building of so-called "classic" architecture to one of more cheering and colorful aspect, suitable as the home of a retail business.

Vacant for Three Years

When, in 1932, the Fifth-Third National Bank was merged with the Union Trust Company, the united banking business was centered in the Union Trust Building. For three years the building vacated by the Fifth-Third National Bank remained vacant — a constant financial drain on its owners. Of even more importance, the presence of this severely classic and empty building in the best shopping section of the city caused the entire block in which it stood to run down as a retail shopping area.

Modernize to Stop Loss

A decision was reached to reconstruct and modernize the building and stop the heavy financial drain. The F. W. Woolworth Company offered to rent the reconstructed building on a six-month lease, while the Woolworth organization was erecting a new structure on the site of its old building. This offer from the chain store people was regarded as a "break," for it was considered certain that after six months of occupancy by Woolworth the former harmful effect of the empty bank building would be completely wiped out.

The Reconstruction

The lot occupied by the building has a frontage of 66 ft. 3 in. on Fourth Street, and a depth of 154 ft. The rear 118 ft. of the original bank building had been built as a high single story, with a clear height of 44 ft. 6 in. from the floor to the bottom of the roof trusses. A balcony extended along both sides and across the rear end. This part of the structure remained unchanged, except for the removal of banking counters and fixtures, balcony and all being occupied by the chain store. Upon termination of the Woolworth lease, a reinforced concrete floor slab will be built as a second floor over this entire lot depth of 118 ft. before the next occupants move in. Likewise, a solid division wall on the longitudinal center line of the building will divide the space into two separate spaces for retail occupancy.

Reference to the "before-and-after" illustration will suggest at once that little could be done with the old classical facade, with its heavy granite columns and the deep recess in front. Aside from this, the story heights of the front 36-ft. depth of the building were too low to be suitable for retail purposes.

Front Is Rebuilt

Accordingly—and wisely, no doubt—the architect decided to remove the part of the building above the first floor slab and back to a line 36 ft. from the Fourth Street front. This part was completely rebuilt in reinforced concrete and steel. Footings for a row of new columns on the longitudinal center line of the building were placed independently, in spaces cut through the basement floor.

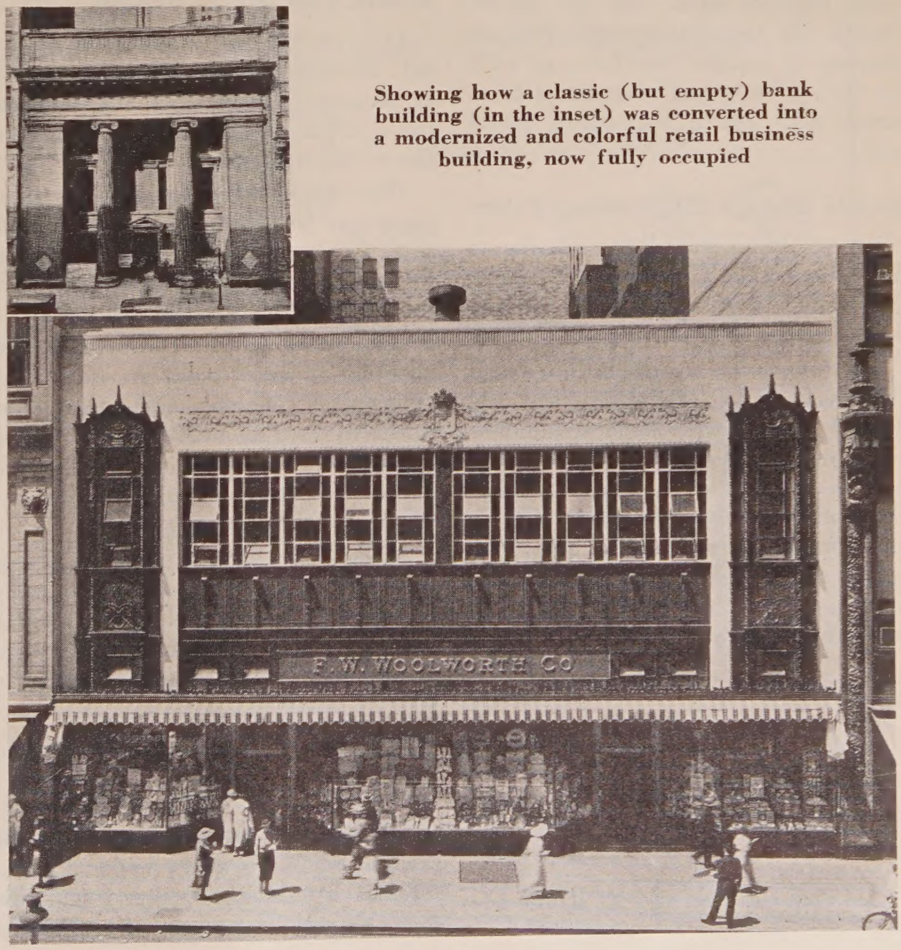
The new front, as the large illustration shows, presents a modern appearance, with ample areas of plate glass and ornamental work of cast aluminum. In the first-story show windows the plate glass extends to within 5½ in. of the property line.

The reconstructed building, when completed, will have a basement and two stories throughout the full depth of the lot.

Speedy Construction

As might be expected, construction operations were seriously hampered because Fourth Street is one of the busiest streets in the city. It was found necessary to carry on a great portion of the work at night, so as not to interfere unduly with traffic. In spite of these handicaps, the reconstruction was completed in 53 days, at a total cost of

(*Continued on page 24*)



Showing how a classic (but empty) bank building (in the inset) was converted into a modernized and colorful retail business building, now fully occupied

Small Dams—
How to Build Them

Details of Concrete Gravity Type—Foundation Problems and How to Meet Them—Other Available Types

INFORMATION of exceptional value to builders of small dams has been issued, in the form of an illustrated folder, by the Portland Cement Association.

The small dam will play an extremely important part in the nation's great program designed to conserve our soil and water resources. There is the small farm dam built to impound a water supply for live stock; the earth-fill and concrete tube dam[1] for stopping the erosion of gulleys and ravines; the individual dam of larger size, built to create a small lake or reservoir as a local resort or water supply; and finally, the series of still larger dams built to impound the waters of an entire district or river valley.

No one type of dam is suited to all purposes; but whether the type selected is a concrete gravity dam, a masonry dam, or an earth-fill or rock-fill type, much concrete work will be needed. Even in the earth-fill or rock-fill types, concrete is required for the core wall, for the spillway, and often for a foundation slab and a foundation cut-off wall.

Should Engage Engineering Talent

Several states have laws relating to the construction of dams. Obviously, they should be consulted before work of this character is undertaken.

The foundation conditions, the extent and character of the water shed and flooded area, and the flood stream-flow are a few of the important items that must be considered. It is always desirable and generally necessary to employ an experienced engineer to prepare a survey and design the dam and miscellaneous devices required. The data given here are offered as suggestions only.

Selection of Type

The selection of the type of dam to be used should be made only after a careful study of local conditions and the advantages or disadvantages of the various types. Any of the types mentioned above will give good service when properly designed, constructed and maintained. When comparing the various types, consideration should be given to safety under all conditions, to first cost, and to cost of maintenance.

Factors likely to cause failure of dams are:

(1) Seepage through the dam;
(2) Insufficient width of base;
(3) Weak or porous foundations;
(4) Water passing around the end;
(5) Wave action;
(6) Water overtopping the dam.

The width of base is a matter of design. Proper design and construction will eliminate failures caused by poor foundations and by water passing around the end of the dam. A cut-off wall, as shown in the drawings, should be used with all except the most impervious foundations.

Where Concrete Is Needed

The concrete and masonry dams are not affected greatly by wave action or seepage. The designs shown allow for a slight overtopping without damage to the structure.

The chances of failure of the other types may be reduced by using concrete core walls and paving. The core wall will prevent seepage, or at least remove the danger of progressive failure due to a leak. Leaks may start through porous material or holes made by burrowing animals. A concrete paving with a toe wall will have about the same effect as a core wall in preventing seepage and will also successfully withstand the erosive effect of wave action.

Special precautions must be taken with earth dams to prevent overtopping at any time. Overtopping of an earth dam will result in failure. To prevent overtopping, adequate spillway capacity must be provided to take are of the maximum flood flow.

Concrete Gravity Dam Is Safest

The concrete gravity dam offers the greatest degree of safety under all conditions. It must have a firm foundation such as rock, hard-pan or well compacted clay and gravel. A spillway should be provided by means of a slight modification of the dam section as shown in the large drawing (Fig. 1).

When this type of dam is set on rock, the surface of the foundation should be thoroughly cleaned and brushed with a rich grout just before concrete is placed. Where necessary to form a horizontal joint during construction, a key should be provided as shown on the drawing.

The masonry dam is quite similar to the concrete gravity dam and requires the same type of foundation. Where a supply of good stone is available and labor is cheap, the masonry dam may be economical. The rock-fill dam may be used to advantage where foundation conditions are not well suited to the use of a concrete or masonry dam. The comparative cost of a rock-fill dam to other types will depend largely upon local conditions. In making a cost comparison the additional cost of such extra parts and devices as spillway and outlets must be considered as well as the additional cost of maintenance.

The earth-fill dam may be used where the soil will not support any other type. However, with rock foundations the other types are preferable because of the difficulty of preventing seepage between the earth-fill and the foundation. Earth-fill dams are generally quite low in first cost, but the cost of outlets, diversion canals and spillways will be more than for a concrete or masonry dam. This type must be very carefully maintained to insure safety. As mentioned before, an adequate spillway is more important than for any other type, as the dam will be destroyed if water flows over it.

Foundations

Soil Foundation. When the foundation material is soil, such as clay or mixtures of clay and sand, the site should be prepared by removing all vegetable matter and soft spots.

Excavate for all masonry to at least the minimum depth shown on the sections of the drawings, and in all cases to firm soil. The bottom of the excavation, at right angles to the dam, should be level or slightly sloping downward toward the upstream side.

Where it is necessary to back-fill, the filling material should be moistened and solidly packed into place.

All drain or outlet pipe should be placed on firm, undisturbed soil, and the back-fill, if any, must be carefully compacted around it.

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[1] See illustrations on page 13 of February (1935) issue of CONCRETE.

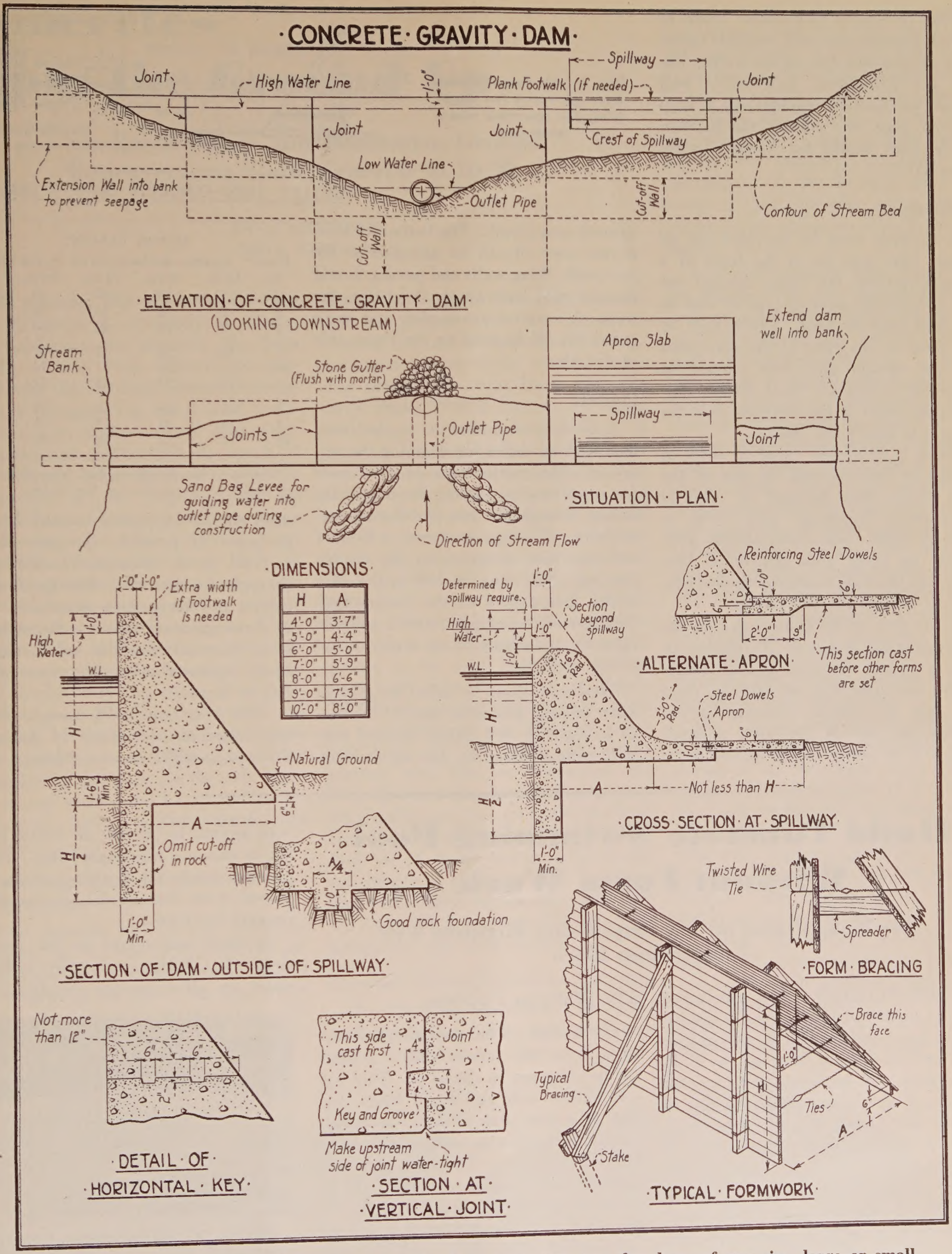


Fig. 1—Construction details of concrete gravity dam, the safest type for dams of any size, large or small

In addition to the above requirements for all dams, the foundation for an earth-fill dam should be plowed lengthwise of the structure so as to form furrows that will increase the bond between the dam and the foundation.

Rock Foundation. Excavations in rock must be carried down to solid material, free from seams, and all loose or broken pieces must be removed. There should be no projections or holes in the sides of the excavation, and the bottom surface at right angles to the dam should be either level or slightly sloping downward toward the upstream side.

Sand or Gravel Foundation. Sand or gravel foundations will require rather deep excavations for cut-off walls. Unless the foundation material is well graded and contains enough soil to keep it from being too porous, the location of the dam should be changed to another site.

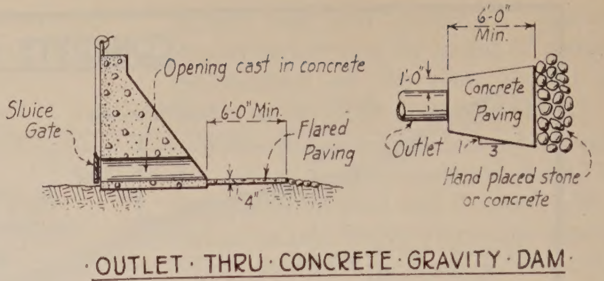


Fig. 2—All dams should have an outlet for emptying the reservoir when necessary

Spillways

A spillway must be provided for all dams. This may be in the form of a canal diverting the water around the end of the dam, or some type of wier in the dam may be used. The bottom of the canal or the crest of the wier must be low enough and wide enough to carry the maximum flood stream flow when the water in the reservoir is at the allowable high-water line.

When a diversion canal is used, it should be built around the end of the dam rather than through it. This is particularly important with earth or rock-fill dams. The canal should preferably be lined with reinforced concrete and the ends protected against erosion by wing walls and paving.

Wiers may be built as shown in the accompanying drawings. Particular attention should be given to the details of the wier used with an earth or rock-fill dam to prevent scouring action around the end of the wier, a detail that will be shown in the article to be printed next month. The bottom or floor of the wier should be attached to the core wall. Wing walls and paving should also be used both above and below the wier. A concrete apron slab and stone gutter should be used on the lower side of the wier.

Outlets

It is very desirable to equip every dam with an outlet for draining the reservoir. This outlet may also be used for conveying any water flowing in the stream through the dam site during construction. In concrete dams, a hole of sufficient size, as given in the accompanying table, may be left in the dam at the lowest part of the stream bed. This should be equipped with a suitable valve or sluice-gate at or near the upstream end.

Great care must be taken to prevent water seeping along the sides of the outlet in earth or rock dams. Several concrete collars extending into the embankment should be placed around the outlet pipe. If possible, the pipe should be laid in an excavation rather than through the dam fill. Details of these collars and the location of suitable valve or sluice-gates are shown in the sketches. It is essential that the valve may be easily operated when the reservoir is full or empty.

OUTLET CAPACITY

Head*	Approx. discharge in cu. ft. per second				
Ft.	12 in.	18 in.	24 in.	30 in.	36 in.
2	7	13	27	42	62
3	8	18	33	52	76
4	9	21	38	60	88
5	10	23	43	67	98
6	11	25	47	74	108
7	12	27	51	81	116
8	13	29	54	86	124
9	14	31	57	91	132
10	14	33	60	95	139

*Head is the height in feet from the center of outlet to the surface of the water.

(The next issue will contain details and descriptions of dams of the earth-fill and rock-fill types.—Editor.)

Build Concrete Swimming Pool Without Form Work

Side Walls Placed on 1:1 Slope—Dry Mixtures Well Tamped into Place

CONSTRUCTION of a reinforced concrete swimming pool without forms was accomplished in an outdoor pool built at Clayton, Missouri, by E. P. Kronsberg. All surfaces were either flat or placed on a slope sufficiently flat to permit the placing of a dry mixture of concrete without need of form work of any kind.

The pool, located on the private grounds of the owner, is 58 ft. long, 31 ft. 6 in. wide at the wide end, and 17 ft. 8 in. wide at the narrow end. Roughly, the plan of the pool is that of a somewhat elongated horseshoe, with the deepest part at the wide end. Here the water has a maximum depth of 7 ft. 6 in. The entire pool is surrounded by a 2-ft. concrete walk.

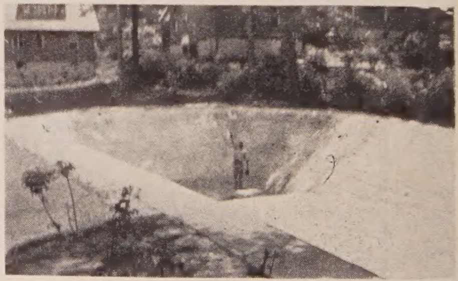
Side Walls on 1:1 Slope

The bottom of the pool slopes downward from the narrow end, but there are two changes in the slope. This bottom (14 ft. wide and 46 ft. long) consists of a 6-in. slab of concrete lightly reinforced with wire mesh weighing 48 lb. per 100 sq. ft. The sides and ends are 4-in. slabs of concrete, similarly reinforced and placed on a 1:1 slope. At the junction of the bottom slab and the sloping side walls the former was provided with a shoulder to serve as a base for the latter.

Joints; Concrete Mixture

Before the side walls were placed, the shoulder in the bottom slab was coated with asphalt to prevent an actual bond, but to insure a watertight joint. An expansion joint, filled with asphalt, was placed in the bottom slab, at one of the changes in slope.

Concrete was mixed in the proportions of 1:2:3½, with only sufficient water to allow proper handling and placing. For the side slopes, especially, the mixture was kept as dry as the requirements of handling permitted, and the concrete was tamped thoroughly into place.



Well-tamped dry mixtures of concrete permitted placing of this swimming pool without forms

Concrete—from the Ground Up

Six-Room Home and Decorative Ground Improvements Show Concrete at Its Best

By L. SCHOLTEN
Gilroy, California

IN planning this six-room dwelling for Harry C. Scholten, at Gilroy, California, the architect, Mr. John Hulla, of Oak Park, Illinois, co-operated with the Portland Cement Association at Chicago. The result is an architectural gem of comfort and distinction, with the cost well within the reach of the ordinary homebuilder. Even though somewhat on the English type, the house, in true California manner, caters to the sunshine, with its many large windows and its airy rooms. There is something about the very appearance of this home that promises solidity, comfort, charm and livableness. There is no tremor of the house on its foundations when the train thunders by several blocks away; no rattle of windows at the passing of heavy traffic; no swaying of the house in high winds. The muted roar, and the sight of the branches of the trees are the only signs of strong winds—the house and its inhabitants know neither creak nor tremor.

Wall Construction Provides Own Insulation

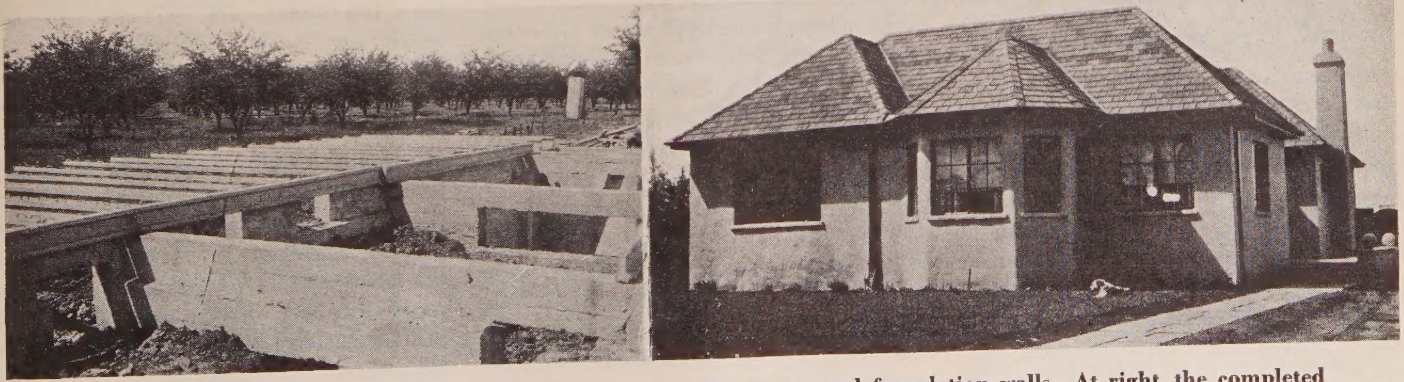
The concrete hollow tile walls are proving to be one of the best investments we have ever made—even at this early stage of the game. On cold winter days, when returning to the house after it has been closed up and the heat turned off since early morning, it is a comfort and a joy to know that we will not be greeted with the breath of clammy chilliness. Instead, there is an inviting mildness to the air that makes it a pleasure to come home after the day's work. With a flick of the finger the heat is turned on, and before the grime of the day's toil is removed, the house is pleasantly comfortable. The hollow walls, insulated ceilings, and concrete floors are so retentive of heat that we were most agreeably surprised at our gas bills during the winter—and these included the gas furnace, automatic hot water heater and kitchen range. Double thickness glass window panes set in steel casement windows add greatly to the heat retention. During these warm days we are no less thankful for our concrete construction. After the hot California sun has been pouring down all day, until the air is aquiver with heat, as one enters the house the cool interior seems to quicken the flagging energies, for the same pleasant coolness dwells there that we shall find out of doors just as soon as the sun begins to drop lower in the west. The first remark of all who come into our home on these warm days is, "How lovely and cool it is in here."

Concrete Floors, Linoleum Covering

The floors are the answer to a housekeeper's prayer. The reinforced concrete floors, cast in place over precast reinforced concrete floor joists, give a rigid construction that will never jitter and never sag. Covered with heavy linoleum, laid over felt, throughout the house, they are a joy to take care of. Especially do the floors in the living and dining rooms carry out the general scheme of "everything concrete," for the design of the linoleum simulates more or less irregular stone tile in warm brown tones, set into a concrete matrix.

A concrete stairway leads down from the kitchen into the storage and furnace room; and separated from the furnace room by an 8-in. poured concrete wall and an insulated door, is another answer to a housekeeper's prayer—a roomy fruit and vegetable storage room. Here are root-vegetable racks of wire netting, deep roomy shelves for canned fruit, and a flood light that shows up every corner. The drop in temperature felt as one enters this fruit room is so noticeable that it never fails to excite comment. The concrete walls and ceilings of the entire basement are washed with white cement, which means that no corners are lost in impenetrable gloom, and gives an air of space and cleanliness. The white cement does not powder and flake off like whitewash; it is permanent and waterproof.

The low spreading roof of cement asbestos shingles in autumn copper shades is an important factor in the charm and individuality of the house. The peak of the roof has been cut to form a deck, and this area was insulated with thick light insulating board in the attic, thus insuring a cool interior. The chimney, also of hollow tile, is lined with flue pipe made of cement concrete in which light-weight aggregate was used. We subjected the tile made of this light-weight aggregate and cement to gruelling fire tests, one of which was to hold a welding-torch three or four inches away from it for three minutes.



At left, precast reinforced concrete joists in place on basement and foundation walls. At right, the completed building

The result was a sharp, hard glaze with the surface pitted only to a shallow depth, and with not a sign of cracks or brittleness of wall.

Concrete Wall Incloses Yard

The three-car garage in the back yard is also of concrete tile. Aside from the house itself, no one thing lends as much charm and individuality to the home as the 6-ft. concrete wall inclosing the back yard. The lot on which the house stands is 72 by 200 ft., and the back yard comprises approximately one half this area. Large square concrete anchor posts were cast at intervals of about 20 ft., and the wall built of 10 by 30-in. tongue-and-groove slabs 2 in. thick, set into a cast-in-place concrete foundation, and strengthened by a reinforced coping cast along the top. The outside of the wall is plastered and finished in the same color and texture as the house—a warm cream; the inside surface was merely color-washed in the same tint, leaving the pattern of the slabs outlined, thus presenting an interesting appearance and a most pleasing background for growing things, and insuring privacy as well as making the grounds a unit with the house. A concrete compost bin was built against the wall near the rear of the lot. We are planning to extend the concrete wall along the west side of the house to the front end of the lot, dropping it, however, from 6 ft. to 4½ ft. in height, thus completely tying in the rear of the premises with the rest of the picture, and providing the necessary background for shrubs and flowers. This is on the side opposite from the driveway.

Decorative Ground Improvement

On the driveway side, leading from the terrace to the street, is a walk of concrete flagstones of various sized rectangles set in a random, non-repeating pattern and tinted a soft neutral green. From the other end of the terrace, concrete irregular-shaped stepping stones lead to the rear gates set across the driveway. The terrace itself is paved with concrete with black cement mortar joints between the simulated flagstones of irregular shape. The charm and the sense of seclusion and privacy which the wall lends elicits enthusiastic comments of approval from all who see it. As time goes on, concrete in many forms—clothes-line posts, curbing, grape trellises, and benches, will be used here and there to make the backyard—the home-lover's kingdom—more inviting, comfortable and convenient.

We feel that our first investment in the concrete construction will be our last cost. There will be no repeated expensive painting of large wood surfaces; no sagging floors, steps and fences; no fear of the insidious and very real danger of termites; no rotting, no warping—and *no fire hazard*. We are happy and secure in the knowledge that when we invested in our concrete home we invested in comfort and permanence.

Harry C. Scholten, the owner of this comfortable and distinctive home of concrete is president of the Concrete Pressure Pipe and Construction Co., Gilroy, Calif.

High-Frequency Vibrators Place Bridge Concrete

Heavy and Light Types of Vibrating Equipment Employed on San Francisco-Oakland Bay Structure

By THOS. E. STANTON, JR.
Materials and Research Engineer, California Division of Highways, Sacramento, Cal.

BECAUSE most of the concrete in the San Francisco-Oakland Bay Bridge is exposed to sea water action, it was deemed essential to provide for concrete fabrication methods which would insure the greatest practical density in all units of the structure.

Internal Type Vibrators

Preliminary to drafting the specifications, a study of the internal methods of vibrating concrete was made by the Materials and Research Department of the California Division of Highways. The study consisted of an investigation of the efficiency of internal vibration by means of a high-frequency vibration unit inserted into the concrete mass at the time of deposit. The internal vibrating unit tested was the *Viber* tamper type in which the vibration is produced by means of eccentric weights rotating on ball bearings inside a vibrator tube. The frequency of vibration was approximately 5,000 r.p.m.

To observe the working of this type of tool, two units—one of the flexible shaft type and one of the rigid shaft type—were tried out on a comparatively stiff pavement concrete as it was dumped from the pavement bucket in a pile on the subgrade. This method was found inefficient when operating in a stiff concrete mass on a rigid base without any form work to provide a kick-back to the vibrations. The operation, while ultimately effective, is slow for pavement construction.

We next constructed a special form to put the vibrator to a severe test in depositing concrete through reinforcement and around corners where the vibrating unit itself could not be brought within less than two feet of the extreme face.

Two batches of 6-sack concrete were placed; one having a water-cement ratio of 0.72 and a slump of 1¾ in., and the other a water-cement ratio of 0.66 and a slump of less than ¾ in.

Stiff Concrete Easily Placed

The first batch was readily vibrated into place within a few seconds after depositing. The second batch, having a slump of but ¾ in. and requiring considerable spading to get out of the wheelbarrows, required more vibration than the wetter mix, but the ultimate result was entirely satisfactory.

This test demonstrated that a relatively stiff concrete could be readily distributed through a reinforcing mat for some distance from the face by means of the internal method of vibration, with not only a uniform distribution of aggregate throughout the mass but also without excess mortar on the faces, the only disturbing factor being the formation of air or water pockets adjacent to the forms.

The test indicated that it is perfectly practicable to use concrete of a much

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Condensed from paper in May-June (1935) issue of the *Journal* of the American Concrete Institute.

stiffer consistency than is usual in reinforced structural work.

Specifications

As a result of these tests and other available data, a paragraph was inserted in the specifications for the Bay Bridge reading as follows:

> The concrete, after having been placed in the forms, shall be thoroughly compacted by means of an approved internal vibrator. The vibrator shall be placed directly in the forms and shall not be attached to either the inside or outside of the forms, nor shall it be attached to the reinforcing steel in any manner.
>
> The compaction shall be produced by inserting the machine in the concrete directly for a period of 20 to 30 seconds. This insertion shall occur approximately every 2½ ft., or where necessary to produce concrete of maximum density. Continuous attention shall be given to the working of concrete next to forms and around the reinforcing steel and embedded fixtures or inserts.

The above requirement for placement of concrete has made it possible to use concrete of a drier consistency on the structural portions of the Bay Bridge work than is customary in this type of construction.

Most of the Bay Bridge concrete is of Class "B," or 5 sacks of cement per cu. yd. The specifications provide a maximum water-cement ratio of 0.85, and a minimum strength at 28 days of 2,500 p.s.i. More than 500,000 cu. yd. of such concrete have been placed to date on the five contracts under way, with an average strength of more than 3,500 p.s.i. and a range of less than 5 per cent in average strength between the different contracts.

Two Types of Vibrators

Two types of vibrators have been used, a small electric-powered type for small units and confined places, and a larger air-powered type for larger masses.

As a general thing, the electric models are best suited for building construction, and pneumatic models on heavy engineering projects.

The volume which can be effectively handled per vibrator depends naturally upon the type of vibrator and the class of concrete.

The specifications around the smaller electric type unit require that the contractor shall furnish and use one vibrator for every 25 cu. yd. of concrete placed per hour. Vibrators on the job are handling from 25 to 40 cu. yd. per hour of mass concrete placed in deep layers. This larger output is handled with the large air-driven vibrators. The maintenance of the equipment is high, couplings and shaft probably requiring the most frequent replacement. Electrical connections are often neglected and, therefore, very often cause delay. The air type motors frequently freeze.

Strong Form Work Needed

We found that ⅝-in. plywood and a tight mixture will hold on an 8-ft. lift. It was found necessary, however, to decrease the spacing of studs in some cases to 14 in. and the wales to 3 ft. and to increase the ties approximately one third. Tightness of forms was found more essential with the internal vibration than with the ordinary hand placement methods.

It was found possible to handle harsh mixes more satisfactorily with the internal vibration method of placement; and, therefore, if harsh mixes must be used on account of lack of availability of materials properly graded for a plastic mix, the internal vibrator is an assurance of more uniform fabrication.

Slumps ranging from 1 in. to 4 in. have been satisfactorily used on the work.

Facts About Placing

The extent to which the mortar proportion could be changed was found to depend on the type of the work. In large mass construction, the mortar may be kept at a minimum; whereas, in thin forms full of steel it may not be found practicable to reduce the mortar content below the standard for hand placement methods.

The concrete should be deposited in layers, although appreciably thicker layers can be handled with vibrators than can be handled with hand tamping.

The distance from the forms with which the vibrators can be satisfactorily handled depends on the mix. In the wetter mixes, the vibrators can be placed closer to the forms than with the dry, stiff mixes. Segregation may occur if the mix is too loose. This is an additional argument for the use of tight mixes. If the mix is plastic, however, it does not tend to spread the aggregate, but does tend to draw mortar toward the vibrator, so that when the vibrator is withdrawn a core of mortar is likely to be left.

In general, the favorable effects of vibration include greater capacity in confined areas, more effective consolidation, better surface. the ability to place drier concrete and to work the concrete around the steel to better advantage than is possible with ordinary hand placing methods.

The cost for labor is somewhat less with the use of the vibrator than without. There is an increase in the cost of the forms. This increase is more than absorbed by the saving in other items of cost, including saving in cost of patching unsatisfactory surfaces. Very little surface patching has been found necessary on the Bay Bridge units. Where rock pockets have occurred in the surface, it has been due either to faulty use or entire lack of use of the vibrator in the defective areas.

Pavement Type Vibrators

The specifications for paving the roadway decks provide that:

> The roadway slabs shall be consolidated and compacted by means of high-frequency vibration applied to its upper surface to expel entrapped air and surplus water, to eliminate all porosity and simultaneously bring the concrete into intimate contact with all embedded reinforcement.

In conformity with these specifications the contractor used two Jaeger-Lakewood automatic finishers with Jackson vibrator attachment, one finisher being approximately 30 ft. long to span the full width of the lower roadway, and the other approximately 20 ft. long to span each one of the three lanes of the upper roadway.

The pavement slab, varying from 6 in. to 6½ in. thick, is heavily reinforced with trusses spaced 7½ to 8 in. centers. The space between the bottom of the truss and the bottom of the concrete slab is but ¾ in. The top and bottom tie rods further increase the cross-sectional area occupied by the reinforcing steel. The maximum size of aggregate is from 1½ in. to 1¾ in. for the lower roadway and 1 in. for the upper roadway, which is of light-weight aggregate.

Paving the roadway slabs has been accomplished with 6-sack concrete with a water-cement ratio of 0.72 and a slump of 2 in. or less is being satisfactorily placed with this type of vibrator. Other than for the first run, where the concrete was insufficiently vibrated, there is complete lack of honeycomb on the under-side of the slab. The compressive strengths at 10 days average 3,000 p.s.i. for the standard aggregate concrete.

Satisfactory results with this method of placement have likewise been experienced on the upper roadway lightweight aggregate concrete, where a 6.5-sack concrete, with a water-cement ratio of 0.60 and 10-day strengths of 2,300 p.s.i., has been satisfactorily placed.

Modernization Big Factor in Recovery

(From Brookmire Special Report on "Modernization and Recovery," July 27, 1935)

Among the potential sources of business in the years immediately ahead, an important one exists in the modernization of existing buildings and equipment of all kinds. Wear and obsolescence have built up a big demand which was deferred during the depression but will be filled as confidence revives and the recovery cycle proceeds.

Individual homes, apartments, office buildings, retail stores, factories, farms, and railroads all can stand a large amount of modernization to attain efficiency and satisfy the wants of the American people.

Building suppliers and manufacturers of equipment of all kinds—together with producers of required raw materials—should be the principal beneficiaries of this development.

NEW construction and other capital projects must be undertaken if the economic recovery is to be maintained and broadened. The point deserving emphasis now is that another promising avenue of business expansion is present in the modernization of existing structures and replacement of worn or obsolete equipment of many kinds.

Homes

In the field of small dwellings, for example, a recent survey disclosed that many millions of them were not only lacking in modern appliances, but were also in a sad state of disrepair. It is encouraging, therefore, to see that a good beginning is already being made in the renovation of such properties. The Labor Bureau, in its compilation of building permits for nearly 800 cities, reports separately a figure for "additions, alterations, and repairs."

As illustrated in the chart, a rise in this type of activity has been in progress since late in 1932. The figures of recent months have exceeded the abnormal bulge of last October and have run far above the average for the year 1934. Indeed, the current rate is the highest since early in 1931.

Considerable stimulus to the renovation of small dwellings has been given by the Government insurance of loans under the Federal Housing Act. The Government, financing agencies, and building suppliers are co-operating in a campaign to popularize home modernization.

This development has far reaching possibilities. Not only can many changes be made in these structures themselves, but in addition a wide variety of modern equipment can be installed — including plumbing fixtures, electrical refrigerators, oil burners, and air conditioning.

Apartments

Earlier this year, the limit on loans carrying Federal insurance was raised to $50,000 in order to broaden the plan to embrace apartment and industrial types of buildings.

Since demand for apartment space has increased materially, and since it has become possible to raise rents, there has been a greater willingness to spend money renovating apartments in order to take advantage of the improving demand. Mortgage interests which acquired property from owners in distress are more willing to incur expenditures now that there is better hope for full occupancy, or perhaps even the sale, of the property.

Offices and Stores

Office buildings appear to be the last to share in the improvement in the general real estate and construction field. Vacancies are finally beginning to decline, however, and renovation work is likely to be on the increase. This should be true particularly of stores.

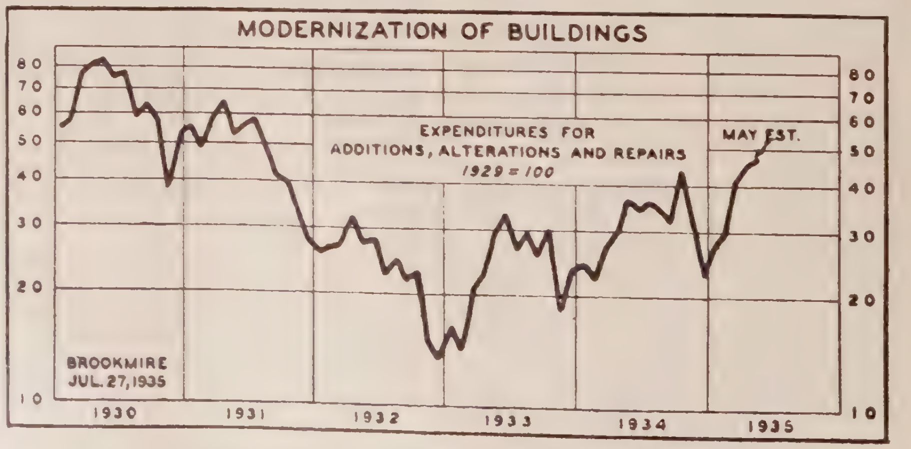
Many of the bigger retail establishments have been devoting much attention to modernization in the effort to attract a larger volume of business and increase profit margins by improving their general efficiency. Modern display cases or counters, better lighting systems, and air-conditioning illustrate the range of projects being considered.

Factories

Industrial concerns also have given increasing attention to modernizing plant equipment. The steps taken by the Government to boost wages accentuated the desire to seek means of reducing costs. The very existence of many industrial concerns depends on getting costs in line to meet competition. Even where plants are relatively efficient, the desire to increase profits means a constant effort to improve efficiency still further. Moreover, costs must be kept low in order to compete in foreign trade.

Tangible evidence of this trend is visible in the rise in machine tool orders to the highest level since 1929. Obsolescence is an important factor here; and when the first show in the machine tool industry since 1929 is held in September, further emphasis will be placed on the superiority of new tools.

It must be remembered that the Supreme Court, in invalidating the NRA, removed the restrictions which had been placed upon re-equipment of plants in many industries. Moreover, the difficulty of financing purchases is eased by the fact that the FHA has been liberalized so that the Government insurance of loans is no longer limited to buildings, but is extended to equipment as well.



How modernization of buildings is aiding progress of recovery

◆ EDITORIAL ◆

Urge Housing Legislation

The National Public Housing Conference recently sent letters to the governors of thirty-one states—those which have failed to grant their cities statutory power to embark upon local rehousing development—urging the calling of special sessions of state legislatures to consider the adoption of municipal housing authority laws.

Referring to the recent ruling by the sixth district of the United States Court of Appeals at Cincinnati, the letter suggests to the governors that the Cincinnati decision places directly upon the shoulders of the states and of local bodies the responsibility for developing housing programs of the slum-clearance type.

The construction industry and the building supply industry are equally interested in this great movement—a development which is coming eventually, court decisions or no court decisions. United action now—in co-operation with the National Public Housing Conference—will hasten the progress toward ultimate success; for, after all, the first thing needed by cities is the legal authority to go ahead.

Modernizing the Business Section

Reconstruction of the Fifth-Third National Bank Building, in Cincinnati, described and illustrated in an article in this issue, again emphasizes the truth of an assertion frequently made in CONCRETE—namely, that one of the greatest opportunities at present open to architects and structural engineers lies in the modernizing of old buildings in the retail business sections of cities and large towns.

In every city and town that is large enough to have a business section worthy of the name, an alert architect can spot old buildings that have possibilities as subjects for modernization.

If there is an architect who thinks the remodeling of old buildings is somewhat beneath his dignity, let him reflect on the accomplishments of Samuel Hannaford and Sons in the reconstruction of the bank building here mentioned. Then let him also turn to the leading article in the July issue of CONCRETE and observe how Graham, Anderson, Probst and White transformed a dingy old brick theatre building into a colorful and artistic example of modern business architecture.

To be sure, an architect who thinks of a problem of this type merely as a remodeling job is not likely to produce anything of an outstanding character. He must have the ability to visualize a new exterior, attached to and supported by the old; and he must also have a broad knowledge of the construction materials and methods best adapted to modernizing work.

The architect who can transform even a few old business buildings into gems of modern architecture will have contributed something of value to his city.

Reinforced Concrete House Details

A book of construction details for dwelling houses of reinforced concrete, just issued by the Portland Cement Association, is a most timely publication that will be welcomed by every architect and every contractor interested in concrete construction—and who, among them, is not so interested?

Many architects and many contractors have puzzled over such matters as details for window openings in monolithic concrete walls—how to build them so as to insure the exclusion of cold air and driving rains. These details will be found in the book.

Other full-page drawings show the details of using standardized metal wall forms of several types, and how to build wall forms of wood and plywood. Hollow walls, double walls, insulated walls—these are also shown.

There are details of the form work for reinforced concrete stairways; heating-duct details; flat roofs and parapets; the thermal insulation of concrete walls, the thermal insulation and covering of flat roofs.

Of special interest to architects is the technical information on the lateral strength and required thickness of various types of concrete walls for buildings of the dwelling-house type.

Days of search would be required for an individual to locate and assemble the information contained in this one volume. Here he will find the details of the things that are really essential.

Where Cast Stone Predominates

Unity Synagogue, in New York City, illustrated on page 15 of this issue, is a forceful example of a type of architecture in which the economy of cast stone is most pronounced.

As a matter of fact, any architectural structure that requires the use of a number of decorative units of identical design offers an ideal advantage to cast stone. Natural cut stone, requiring painstaking work on each individual unit, regardless of the number of repetitions, is hopelessly beaten on the point of economy.

PROGRESS—In a Page

Current activities in research, in matters pertaining to concrete and cement, as being carried on or completed by various organized groups.

Raise Question of Testing Concrete Brick Masonry

In reply to an inquiry from the editor of CONCRETE, concerning the status of long-standing plans to conduct tests of concrete brick masonry, The National Bureau of Standards writes, under date of July 23:

"Your letter of July 17 regarding tests of concrete brick masonry has been received. At the conference between representatives of the clay, sand-lime and cement brick industries, mentioned in Research Paper No. 108, plans were made for this Bureau to co-operate with these industries in a research program on the strength of brick masonry. The investigation reported in Technologic Paper No. 276 was carried out with the co-operation of manufacturers of sand-lime brick and that described in Research Paper No. 108 was conducted with the co-operation of the clay brick industry. Due probably to conditions in the cement brick industry, since the date of the conference (1921), that industry has not yet requested this Bureau to carry out the proposed tests of concrete brick masonry."

Tentative Standards Adopted

AT the Detroit annual meeting of the American Society for Testing Materials the society accepted 47 new tentative standards, and revisions of 49 existing tentative specifications and methods of test. Of the 47 new tentative standards accepted, the following are related to concrete and the products of concrete:

Specifications for:

Axle-Steel Concrete Reinforcement Bars (A 160-35 T). *Commiteee A-1 on Steel.*

Concrete Irrigation Pipe (C 118-35 T). *Committee C-13 on Concrete Pipe.*

Reinforced Concrete Culvert Pipe (C 76-35 T) (revision of tentative standard). *Committee C-13.*

Method of:

Making Compression Tests of Concrete Using Portions of Beams Broken in Flexure (C 116-35 T). *Committee C-9 on Concrete and Concrete Aggregate.*

Determining Voids in Coarse Aggregate (C 30-35 T) (revision of standard). *Committee C-9.*

Test for Amount of Material Finer than No. 200 Sieve in Aggregates (C 117-35 T). *Committee C-9 and D-4 on Road and Paving Materials.*

Test for Soundness of Fine Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (C 88-35 T) (revision of tentative standards). *Committee C-9.*

Test for Soundness of Coarse Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (C 89-35 T) (revision of tentative standard). *Committee C-9.*

Concrete Irrigation Pipe Specifications

THE June annual meeting of the American Society for Testing Materials voted to publish, as a tentative standard, the *Proposed Specifications for Concrete Irrigation Pipe* submitted by Committee C-13 on Concrete Pipe.

The committee also proposed the adoption, as standard, of the existing tentative specifications covering non-reinforced and reinforced concrete sewer pipe, respectively. The society is now balloting on this recommendation.

Tests for Concrete Aggregates

AT the last annual meeting of the American Society for Testing Materials, Committee C-9 on Concrete and Concrete Aggregates reported the development of three new proposed standards which will be published as tentative. These cover compression tests of concrete, a method of test for the determination of voids in coarse aggregate for concrete (dry rodded), and a method of test for determining the total quantity of material finer than a standard No. 200 sieve in aggregates.

List of Federal Government Purchasing Offices

THE U. S. Bureau of Foreign and Domestic Commerce has prepared an unofficial list of purchasing offices of the Federal Government, which includes not only the main offices in Washington but also the field purchasing agencies all over the United States. This is the first time that such a full list has been made up by any Government department.

This list should be of practical use to any firm interested in selling machinery, equipment, or supplies to the Federal Government.

Copies may be obtained free of charge by writing to the Machinery Division, Bureau of Foreign and Domestic Commerce, Washington, D. C.

Drafting Room Standards

THIRTY national organizations and a number of individuals have developed a graphical "dictionary" of drawings. The work has been adopted by the American Standards Assocation, 29 West 39th Street, New York City, and will be used as the guide in thousands of drafting rooms throughout the country.

The Society for Promotion of Engineering Education and the American Society of Mechanical Engineers took the leadership in the work and were sponsors of the project.

A.S.T.M. Meetings in 1936

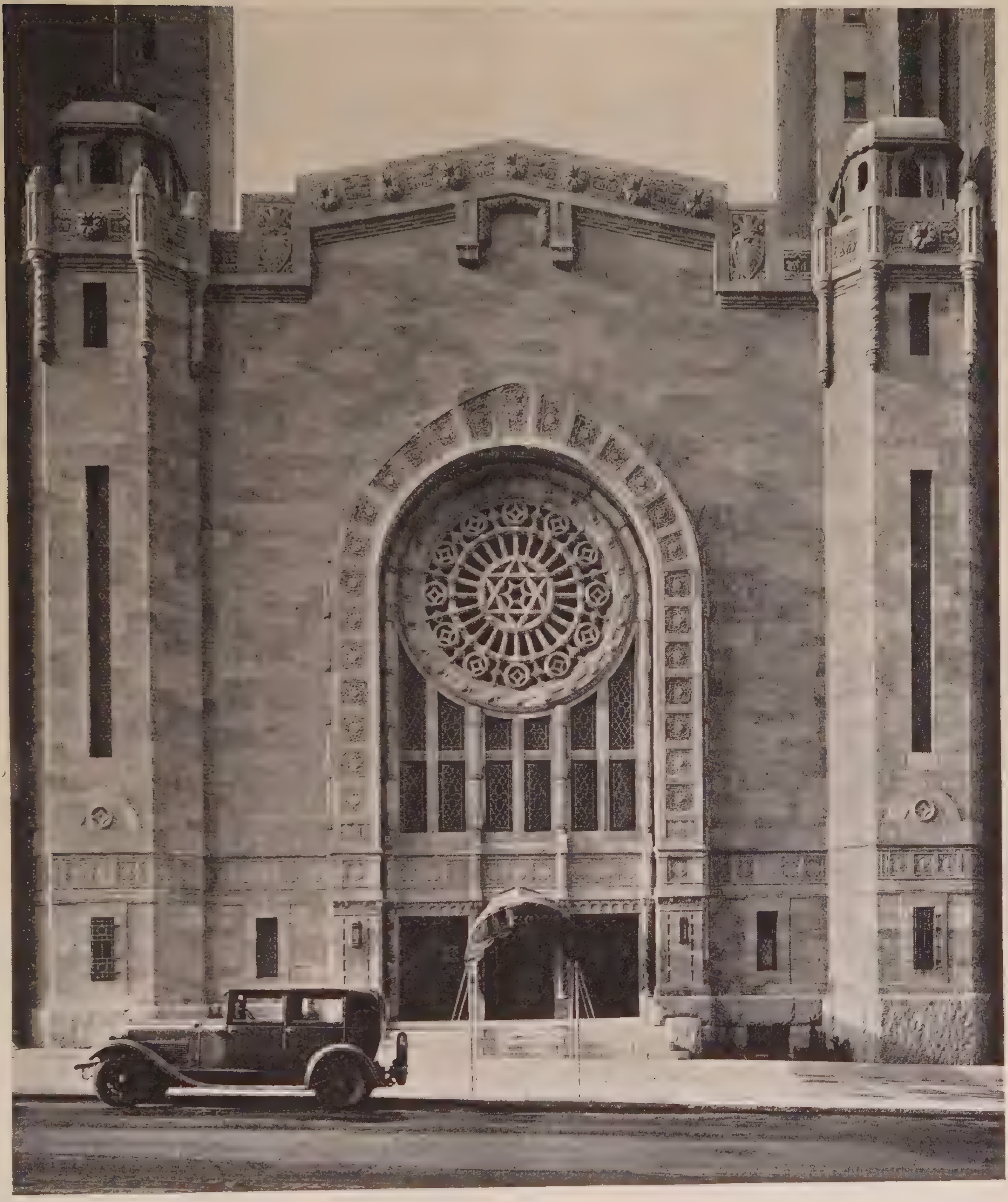
THE 1936 annual meeting of the American Society for Testing Materials is to be held in Atlantic City from June 29 to July 3, inclusive.

It has been decided to hold the 1936 regional meeting in Pittsburgh on Wednesday, March 4. Arrangements for this will be sponsored by the Pittsburgh district committee. The program committee is developing a symposium on high-strength constructional metals, and the committees of the society interested in this program are taking part in its development.

Quick Determination of Magnesia

WHERE specifications for cement do not require complete chemical analysis and place limits upon the amount of magnesia allowable, quick methods of determining this are desirable. Committee C-1 on Cement, of the American Society for Testing Materials, is working on this problem, and has also inaugurated work involving the determination of manganese oxide and ferrous oxide.

Architectural Concrete



Walter B. Schneider, *Architect.*

Cast stone is shown at its best in the Unity Synagogue, in New York City. In this facade most of the decorative elements are repeated—some of them many times. It is in this repetition of ornamental units that the economy of a cast product is most definitely established. Walter B. Schneider, architect.

New Practice in Concrete Highway Joints

The Problem of Expansion and Contraction Joints—Facts from Road Survey—Transfer of Loads Across Joints

The valuable discussion here presented is taken from a paper on "What Is New in Concrete Paving Practice," presented at the twenty-first annual Purdue Road School at Purdue University by V. L. Glover, engineer of materials, Illinois Division of Highways, Springfield, Illinois.—Editor.

THE history of concrete paving practice in the United States may be summarized by stating that it first went through a period of slow development, with relative uncertainty as to the adequacy of various construction practices, then through a period during which some of the most troublesome uncertainties were eliminated by empirical methods, and finally through a period of development and application of scientific principles.

Recently a new type of longitudinal center joint has been proposed and adopted by some states which provides a continuous bar interlaced through the joint in place of the tie bars used generally heretofore. This design has been found to possess desirable qualities as far as construction operations are concerned, and it also affords better distribution of steel along the center joint.

EXPANSION AND CONTRACTION JOINTS

One of the most important changes in paving practice in Illinois during the past two or three years has been the use of a new type of joint to take care of expansion and contraction in the concrete. During the period of intensive construction of concrete pavements in Illinois, neither expansion nor contraction joints were used. Illinois, like many other states, proceeded on the theory that it was more economical to permit cracks in the newly constructed pavement to occur naturally than to provide for expansion and contraction. Furthermore, it was the belief that no satisfactory type of expansion and contraction joints was available.

An Old Problem

That the use of the transverse joint is not of recent origin is evidenced by the fact that some of the oldest concrete pavements were provided with such joints. In Professor Ira O. Baker's *Treatise on Roads and Pavements,* which was first published in 1903, a section is devoted to the subject of contraction joints in portland cement concrete roads. In view of our present knowledge of the use of expansion and contraction joints, a quotation from this section is interesting:

> "Concrete expands and contracts with changes of temperature and moisture. Since the pavement is ordinarily laid in warm weather, the contraction is likely to be greater than the expansion; and besides, the concrete can resist the compression due to expansion better than the tension due to contraction. To prevent the formation of unsightly and irregular cracks due to contraction, it is customary to provide contraction joints at regular intervals. If the pavement has curbs, longitudinal contraction joints are also provided at each curb. Concrete roads and pavements are usually provided with transverse contraction joints from 25 to 75 ft. apart, usually 50 ft.
>
> "Sometimes the contraction joints are placed on an angle with the length of the road, which is an advantage if there is either an elevation or depression at the joint; but if the joints are properly made and maintained, the extra length is only a needless expense; and besides, it is very difficult to strike the surface adjacent to the diagonal joint.
>
> "A number of attempts have been made to determine mathemically the proper distance between contraction joints; but there is so much uncertainty in each of the factors of the problem that any such computation is practically worthless."

An Early Joint

One type of transverse joint described by Professor Baker consisted of a soft steel ¼-in. plate on each side of a ¼-in. sheet of mastic. The plates were provided with projections to tie or bind them securely to the concrete. Some joints of this type were actually installed in some of the older pavements in Illinois and were known as "armored" joints. As noted in the above quotation, it was thought that joints of this type placed at an angle provided better riding qualities, and it was further the belief that this feature would result in a slight lateral displacement of the pavement during periods of expansion rather than compression failures in the form or blow-ups.

The belief that transverse joints were necessary, or at least desirable, therefore, has occupied the minds of some engineers practically throughout the entire period through which concrete pavements have been constructed. For several years, however, the opinion prevailed that transverse joints in rural pavements, while perhaps desirable, did not provide benefits commensurable with their cost. The objections chiefly voiced were that they did not reduce the total number of transverse cracks, each joint being considered as the equivalent of a crack; that the construction technique and the fact that the joint fillers extruded produced rough riding pavements; and that failures due to heat expansion could be repaired with far less expense than the incorporation of joints.

Perhaps the unsuitability of various premolded joints and joint fillers developed during the past decade was partially responsible for the unpopularity of transverse joints in concrete pavements; but it was not until the behavior of large mileages of concrete pavements had been studied for several years that the need for such joints was thoroughly understood. Not only was it shown clearly that any transverse crack was a weak point in the slab, which properly should be taken care of in design, but it was found that compression failures due to heat expansion increased with the age of the pavement. Furthermore, the frequent occurrence of blow-ups became a great menace to the traveling public.

All Pavements Need Joints

All pavements, practically without exception, need some expansion space. Even though they may be constructed when temperatures are the highest, the curing methods generally employed will not permit a pavement to set in its most expanded condition. If the pavement is not kept wet, shrinkage will occur during setting which will result in transverse cracks; and when subsequent contraction due to low temperatures occurs, further transverse cracking will occur. These cracks, alternately opening and closing, will in a few years become filled with foreign material and occupy the expansion space provided by such cracks, and blow-ups will follow shortly thereafter. The sealing of cracks with asphalt or other material has been found wholly ineffective in preventing the entrance of water and the infiltration of foreign materials. Obviously, the only remedy is to provide at proper intervals sufficient unobstructed expansion space which cannot be filled with foreign materials.

But this is not the only reason for the need for transverse joints. It was mentioned previously that any transverse crack constitutes a weak point in the slab; that is, two edges of uniform thickness not mutually supported. That edges of the same thickness as the center of the slab are weaker than the center is recognized in thickening the outside edges. In order to prevent such weak places in the pavement, it is obviously necessary to predetermine the locations of the cracks and insert proper load-transfer devices at such places.

While joints of the premolded type and those employing poured fillers have been used in the past, the material used in such joints will compress more or less permanently or extrude when the pavement expands; and when the pavement contracts, it will not fill entirely the space originally occupied, leaving some space which will be filled with foreign materials. Repeated expansion and contraction of the pavement will eventually permit sufficient foreign material to enter the joint to render it of little value. The most that can be said for such joints is that they delay the failures of the pavement which inevitably must occur.

Facts from Road Survey

During the year 1928 the U. S. Bureau of Public Roads, in co-operation with the Illinois Division of Highways, made a complete condition survey of 1,140 miles of concrete pavement in Illinois. On 310 miles of this pavement built between the years 1919 and 1928, 61,721 transverse cracks had occurred at an average interval of 27 feet; 229 blow-ups had occurred, or one to every 1.35 miles of pavement. On the remaining 830 miles built between the years 1923 and 1928, 84,561 transverse cracks had occurred at an average interval of 52 feet; 258 blow-ups had occurred, or one for each 3.22 miles. The survey indicated that the number of transverse cracks and blow-ups increase as the age of the pavement increases.

Because of the large number of transverse cracks and blow-ups in the pavement due to expansion, the Division of Highways in 1928 adopted the practice of constructing in the pavement 4-in. open joints at intervals of from 800 to 1,000 ft., later filling them with asphalt. These open expansion joints were not installed with the idea of preventing the extensive cracking which takes place, but to prevent or delay the occurrence of blow-ups.

The Four-Inch Open Joint

During the year 1932 a detailed examination was made of the pavements which had been built up to that time. Between the years 1922 and 1931, 4,633 miles of pavement had been constructed without expansion joints, and during that period of time 3,940 open expansion joints had been cut into the pavement to relieve expansion forces. Nevertheless, 3,400 blow-ups occurred, or one for every 1.36 miles, a close check of the interval determined by the previous survey. Four-inch open joints had been installed in 3,417 miles of pavement, and measurement of these joints indicated clearly that they were closing at the rate of approximately one inch per year, so that at the end of a 4-year period they would be practically closed. Therefore, the use of the 4-inch open joint spaced at long intervals simply prolonged for about four or five years the time before blow-ups might be expected to occur.

Up to this time no satisfactory type of expansion joint designed to be installed at close intervals had been proposed. It is true that one particular type of joint had been proposed for a number of years but it had not been perfected to the point where it was of any practical value. After thoroughly considering the data gathered by investigation of the pavements already constructed, it was decided early in 1932 to install experimentally as many different types of expansion joint as were available, and to observe their action with the idea of changing our policies relative to the use of expansion joints.

Air-Cushion Joint Shows Promise

The practice of installing 4-in. open joints in the pavement and the noticeable defects of these joints had interested a number of commercial concerns in the design of a mechanical joint to replace the open joint. It was thought that if a satisfactory type of mechanical joint could be developed, the intermediate cracking could be controlled by proper contraction joints. Altogether, ten individual types of joint, manufactured by nine different concerns, were installed in about thirty miles of pavement. With the exception of two of these types, however, they were all designed to be installed at long intervals and no provision was made to prevent the formation of natural cracks between the expansion joints. Of these two types, one consisted of the regular pre-molded expansion joint which had been in use for a number of years, and the other was a type of all-metal, air-chamber joint. Careful examinations of these installations were made periodically, and it soon became evident that the expansion joints spaced at long intervals were not satisfactory, and that this type could not be used successfully for the reasons already mentioned. Furthermore, all of the joints designed to be installed at long intervals showed mechanical defects which would prohibit their successful use. Out of all these installations only one type of joint, namely, the metal air-cushion joint, showed promise. Certain defects appeared in this joint during the installation, but these were of such nature that they could be and were subsequently corrected.

Three Types Approved

In addition to the expansion joint, a satisfactory type of contraction joint was offered. During the year 1933 this type of joint was installed in approximately 350 miles of pavement. During the latter part of 1933 another joint involving similar principles, but with a different method of load transmission, was installed experimentally in about ten miles of pavement. Several defects appeared in this joint during the installation, but these were corrected and the joint admitted for general use during the early part of 1934. A considerable mileage of pavement was built during 1934 including this type of joint. Further defects were disclosed during the installation on a large scale, the correction of which is under consideration at this time.

Another type of air-cushion joint was installed experimentally in 1934, and this has just been approved for use, so that at present we admit three different types of expansion joints, all of which utilize the air-cushion principle.

All these joints possess the common feature of a U or V-shaped copper seal across the top of the joint, which seal is bonded with the concrete on each side of the opening. In two of the types, this seal is extended across the ends to provide a watertight end closure. On the third type, a sliding end closure is provided. These features permit a change in the width of the joint without injury to the seal and definitely prevent the entrance of water and the infiltration of foreign material through the top and ends. In the expansion joints, the expansion space is enclosed by thin steel side walls and bottom, the side walls serving as a form against which the concrete is deposited. These side walls are merely for construction purposes and are of no use after the joints are properly installed.

The contraction joints initially contain no expansion space. They consist essentially of a strip of metal holding the copper seal in position while it is being placed in the concrete. The strip of metal need not necessarily be continuous, and it either produces a weakened plane which will result in a transverse crack or it may extend to the subgrade, thus forming the joint.

Load-Transfer Devices

Both expansion and contraction joints are provided with a load-transfer device. Two of the types employ dowel bars alternately bonded to one or the other side of the joint and free to slip at the other side. The other type employs a load-transfer device consisting of structural steel angles in short lengths placed alternately in such a manner that one leg is fastened into the vertical face of the concrete, on one side of the joint by means of lugs cut from the angle and bent so that they may be embedded in the concrete, and the other leg extends under the concrete on the opposite side of the joint. The angles are alternated in order to provide load transfer from either side. The horizontal projections of the angles are enclosed in a metal sleeve to provide for movement of the angles.

For protection either the copper seal on all types of joint is covered with a premolded bituminous cap left in place or a suitable poured filler is applied. Expansion joints are spaced at intervals of 90 ft., with two contraction joints between, providing a maximum panel length of 30 ft.

As mentioned in the quotation from Professor Baker's book, it is practically impossible to determine the spacing of joints mathematically. The spacing which we are using in Illinois was determined from the results of the crack survey previously mentioned and represents our best judgment as to the panel length which will function without the formation of additional transverse cracks.

Most Cracks on Fills

Investigations are under way to secure definite data relating to the cracking which has occurred in the pavements in which joints have been installed. In most of the instances where cracks have occurred between joints they are clearly the result of adverse subgrade conditions. At present it is quite definitely established that essentially all cracking between joints occurs on fills and in cuts and that serious cracking has occurred only over deep fills. It is estimated that between two and three times as many cracks have occurred on fills as in cuts, and that where there is no fill or cut of any consequence cracks occur at the rate of only about one to each 3,000 joints. The few cracks which have occurred outside of fills and cuts are nearly all at points of non-uniformity of subgrade, such as at culverts. The fact that transverse cracking is not wholly controlled by the joints where the pavement is placed on fills and in cuts indicates that soil studies may profitably be made to determine the proper steps for their prevention.

Warping

Some warping or heaving of the slab has occurred adjacent to some of the joints installed during 1933 which did not have watertight end closures. These defects were not apparent during the first winter, but weather conditions have been such during the fall and winter of 1934-1935 as to promote warping. This indicates that difficulty will be encountered with warping or heaving if the top seal and end closures at least are not made watertight. It is not sufficient just to exclude foreign material. It might even be necessary in the case of certain soil and drainage conditions to seal the joint completely. We are now conducting a thorough investigation of the cause of the warping which has occurred and data relative to this will be available later.

The whole subject of expansion and contraction joints is very interesting and much time might be spent in a technical discussion of the action of concrete due to temperature changes and the effect of weathering, the necessity for joints, and the details of the design of joints and their installation.

Construction Contracts Continue Increase

Residential Construction Has Big Gain Over Last Year

According to the F. W. Dodge Corporation the contract total for all classes of construction, reported for July in the 37 eastern states, amounted to $159,249,900, exceeding the monthly volume reported for any other month since March, 1934, when the PWA was at its peak. During June the volume was $148,005,200, while in July of last year the total was only $119,662,300.

The chief item of significance in the July record is to be found in the continued activity in the residential field, as distinguished from other classes of construction. For residential building, the July total amounted to $48,371,800; this was almost 2½ times the volume reported for July, 1934. The residential total for July slipped about 3 per cent from the June contract volume of $49,832,600, but that is less than is customary at this season of the year.

Improvement in residential building over July, 1934, was shown in each of the major geographic areas east of the Rocky Mountains, with the sole exception of the New Orleans territory (Louisiana and Mississippi combined). The largest relative gains were reported in the Middle Atlantic states, the Southeast, the Chicago territory and the Kansas City district.

For the first seven months of 1935 residential construction contracts in the 37 eastern states totaled $256,545,400. This is in excess of the total for all of 1934, and compares with a total of only $151,592,500 for the corresponding seven months of last year.

It is encouraging that more recent reports show contracts awarded in increasing volume during August.

The Concrete Products Manufacturer

Association Activities + + + News of the Industry

CONCRETE products manufacturers have reason to feel greatly encouraged over the present situation and the future outlook in their industry. In his current news letter beginning on this page, "Spec" Collins emphasizes above all things the constantly widening markets for concrete products—markets that are being widened not only because of the resumption of construction activities that have, in the past, brought business to products manufacturers, but also because these products have won additional victories in the battle for acceptance. They are now permitted in government specifications which formerly ignored them. They have gained the favor of architects who now realize their mistake in overlooking them so long.

Let it be remembered, too, that Mr. Collins had much to do with the winning of this wider recognition.

Concrete Masonry Industry + News Letter +

Home Construction Continues to Be Bright Spot in Recovery Parade — Where Products May Be Sold

By D. R. COLLINS

Assistant Secretary, National Concrete Masonry Association,
33 W. Grand Ave., Chicago

HOUSING continues to be the bright spot in the construction picture. Concurrently with a record-breaking volume of business in this field as compared with last year comes the report that the Federal Housing Administration is weekly shattering records on the number of insured mortgages as well as modernization and repair notes. A report of August 13 indicates that modernization and repair notes have been insured by the Administration to the extent of nearly $115,000,000. It also insured a total of $57,000,000 worth of mortgages.

The Federal Housing Administration continues to look like the one New Deal agency that is doing the most for products manufacturers. Not only has it made the public conscious of the need for home repair and new home building, but it has created a much easier method of financing such projects than was available prior to its formation. In addition to the figures listed above, the Administration feels that probably five times as much business has been created, modernization has been insured, and at least an equal volume of new construction has been stimulated.

Regulations as now modified allow the insuring of loans up to $50,000 each to be used for the improvement of such large structures as apartments, stores, factories, offices, theaters. This automatically widens the market for concrete products used in partitions, basements, fronts, walls, for the repair of such structures.

G E Promoting Low-Cost Houses

As a further step in the development of their New American home program, the General Electric Company last week released plans for a home in the $5,000 class requiring less electrical equipment than necessary in its original plan. It hopes to have some 500 of these homes built before the first of October. If you have not contacted your General Electric Company dealer or distributor in your territory, do so at once! These homes will be publicized widely, and they offer a splendid publicity medium as well as an outlet for your materials.

Concrete Houses Get Publicity

Leading magazines continue to feature newly built concrete masonry houses. The major part of the material being published shows a definite trend toward fireproof construction. Unquestionably the concrete masonry industry has the answer to this type of construction when it must be combined with economy. If you have photographs of concrete masonry houses for which you have furnished units during the last six months, be sure and send them to the Association together with information that can be used in making readable magazine or news stories.

Much is appearing in the papers of late about the low-cost housing plans of the Federal Emergency Housing Corporation—the division of PWA that builds and maintains slum-clearance projects. The government is specifying concrete masonry as an option with other masonry materials for these projects. The Association will be glad to help you follow through on any specific jobs. At the present time the first of these jobs completed on which concrete masonry was used, to a large extent, was the *Neighborhood Garden Development* at St. Louis. Effective use of both plain and ashlar units was made on this project. At the present writing it appears that concrete masonry units will undoubtedly be used in a large project in Indianapolis to be started soon, and manufacturers report that they are working on several other projects which have not yet been granted.

Norris House Satisfactory

While on a vacation during the past month the writer took the opportunity to visit the housing development at Norris, Tennessee, where some 150 houses were constructed of cinder units. There have been several rumors of late that

Cinder concrete wall units and precast concrete joist and slab floors solved the low-cost fireproof home problem in 150 of these houses at Norris, Tenn.

these houses were not satisfactory—started, as far as we have been able to learn, by competitive interests with a little "whispering campaign" of their own. This visit was made on a Sunday morning, when the workers were at home. They were sincere and enthusiastic in their commendation of this type of construction. The houses at Norris may be termed "low-cost houses," and were built in direct competition with other less permanent materials as far as cost was concerned.

Certainly this development at Norris demonstrates the practicality of concrete masonry in the low-cost housing field. All of these houses are one or two stories in height, all have precast joist-slab floors, are painted directly on the block both inside and out. Although the writer asked the most negative sort of questions concerning the houses, he found the people living in them inclined to disagree with the criticism of the type of construction. On the other hand, they declared the cinder block house to be dry, livable, and entirely suitable for projects of this sort.

Under the Rural Rehabilitation set-up, it is probable that many such villages will be built during the next couple of years. Certainly products manufacturers should follow through every such project within shipping radius and use the material that the Portland Cement Association has prepared on this type of project to sell concrete masonry.

A New Ashlar Book

The Portland Cement Association has just published a new booklet, *Concrete Ashlar Walls*, which, incidentally, is one of the finest contributions that the Association has made to products literature. The book is made up mainly of illustrations, only enough text being used to explain what ashlar is and how it can be used. A number of manufacturers have already obtained extra copies of this book to aid them in their sales work. If you have not received a copy by all means write for one. After looking it over I am sure that you will agree that it can be made a powerful sales tool to help you in the promotion and sale of this type of material. Ashlar gives the products manufacturers access to a higher type of construction and larger jobs than those they have ever been able to bid on before. It seems an answer to quantity production. *More about ashlar next month.*

A number of ashlar jobs are in progress at the present time which we will tell you about. As in the case of houses, if you have any ashlar jobs going, get a commercial photographer to take pictures of them and use these pictures in your sales work. And don't forget to send the Association extra copies of the prints.

Concrete Joist Floors

Concrete joist floors still continue to be accepted in the high-grade and low-cost residential field as the type of construction which brings the permanent firesafe floor within the reach of prospective home owners. Many plants which last year sold only one or two jobs, but thus secured a foothold, report sales running up into the 10's and 20's for 1935.

Like ashlar, a good demonstration job is needed to put across and familiarize architects and builders with this type of construction. The first job is often hard to get, but the second comes much easier —and from then on the procession of business starts. Surely, no one individual development in the products field for the past four years has caught the popular fancy that this one has, or has made such advances. The Association will be glad to supply information on the manufacture of joists and further information that you can use in talking to architects and builders.

Many Plants Making Repairs

Correspondence from the manufacturers of machinery indicates that during the past four months the pick-up in repair and parts business has been more than in any time during the past five years. While not many new machines have been purchased, there is sufficient volume of repairs and replacements to indicate that business is going ahead in a substantial way. Certainly this is most encouraging and a true indication of the status of the business.

Ben Wilk Writes

In a letter written by Ben Wilk a short time ago he makes the following statement:

"It seems to me, after my talk with the architect on the Oakland Housing, Inc., subsistence homestead project, that we should harp frequently on this sort of work. There are many angles that could be emphasized, and one that strikes me at this time is that if the government goes ahead and uses our concrete units for above-ground walls and finds them suitable for low-cost projects, we should find an ever widening field for the use of concrete masonry. We know that from an economical standpoint concrete units are perhaps the best available. The question usually is, 'How can they be used to build an attractive and durable home?'

"The big question is resale value. Today, in the city of Detroit, we are thinking mostly in terms of face brick-veneer. The average purchaser of a home wants to know that there is a full resale value in a house in case he has to sell it."

With the government now talking of making the amortization period 60 years for projects such as Ben speaks of, instead of 40 years, there can be no necessity or economy for other than permanent fireproof construction. As in the Norris village project and the houses at the St. Louis *Neighborhood Gardens House Project*, concrete masonry should be the solution to this problem and undoubtedly will be given favorable consideration if brought to the attention of those in charge of projects of a similar nature.

Block Manufacturer Finds Market in Coal Mines

Replaces Brick as Material for Fire-Stops in Mine Shafts in Pennsylvania—Products Plant Kept Busy

GEORGE GOUIRAND, owner of Chartiers Cinder Tile Company, located near Canonsburg, Penna., when not busy in the plant, used his time to promote and extend the use of his products.

It occurred to him, after reading a booklet entitled *Less Cost per Ton*, published by the Portland Cement Association, that he might be able to persuade one of the local coal mining companies to use his cinder block for fire-stops in mine shafts.

He called on John Bartarna, who was then superintendent for the Pittsburgh Coal Company, and persuaded him to try his cinder block for fire-stops. Some of the blocks were delivered to the Pittsburgh Coal Company's laboratory, tested and found to meet the requirements of the state mine inspector, who approved them.

Construction of stops with block was found to be more economical than with common brick, which the coal company had been using.

The result of this good work in salesmanship has been that this small plant has been kept busy practically every day for months. They deliver to the coal company from one to four thousand blocks every month, and the average is about two thousand per month.

The products plant now has all the work it can handle, in the filling of the mine orders and the regular orders that come in.

Cinder concrete block wall in coal-mining shaft serves as effective fire-stop

News of the Products Industry

Eastern Plants Making Manhole Blocks

Three concrete products manufacturers in Massachusetts—A. A. Cassese, at Weymouth; P. Tebaldi, at Indian Orchard; and New England Concrete Pipe Co., at Newton Upper Falls, have recently installed equipment for making concrete manhole blocks. The new equipment in each case consists of a simple low-cost attachment for the Besser plain pallet stripper which enables them to make manhole blocks on the same plain pallets used for all other types of block and involves no additional pallet cost.

The Spartanburg Concrete Company was incorporated with $500 capitalization and J. L. Von Glahn and W. C. Smith as officers. — *Columbia, S. C., Record.*

The *Concrete Plank Co., Inc.*, has recently been incorporated in Jersey City, N. J., to manufacture concrete products.

Concrete Piles for Gymnasium

The Whitney Construction Company, of West Allis, Wisconsin, has been awarded the contract to furnish all materials, labor, tools, and equipment necessary for the complete installation of concrete piles required for the construction of the new Nathan Hale Junior High School gymnasium. Whitney's bid of $54 per pile was the lowest of the four bids received by the board of education.

Public Works Using Concrete Manhole Block

The Cherrydale Cement Block Company, of Cherrydale, Virginia, has recently installed equipment for making various sizes of manhole blocks to supply the demands for this type of unit which is being used in a public works construction program. The same equipment, a Besser plain pallet stripper block machine, is also being used to make various building block and tile. Only one set of pallets is necessary in making these different units.

Factory Contracts Awarded

Contracts for a 3-story brick and concrete block factory at Marshfield, Wis., for Albert H. Weinbrenner Shoe Company, moving from Milwaukee, have been awarded.

The structure, with part basement, will be 52 by 271 feet, with office and boiler room additions. Labor for the superstructure will be furnished by Marshfield Construction Company.

Other awards were to Federal Steel Sash Company, Waukesha, and Wausau Iron Works. The architect is G. A. Krasin, Marshfield.

Bids for the furnishing of 600 concrete buoy weights were invited recently by the Memphis engineer district.

The weights are used as anchors for buoys employed in making channels in the Mississippi River.

Justin W. Hough, 35, superintendent of the Metropolitan Concrete Co., died suddenly recently at his home, 1715 E. 115th St., Cleveland. He came to Cleveland about six years ago. He was born in Elmira, N. Y., and lived for a number of years at Youngstown.

Strength of Monolithic Concrete Walls

University of Illinois Tests Show High Compressive and Lateral Strengths in Walls Commonly Employed in Concrete House Construction

TESTS to determine the strength of monolithic walls have been concluded at the University of Illinois and the results have been reported in *Bulletin No. 277*, under the title of *The Strength of Monolithic Concrete Walls*, and under the authorship of Frank E. Richart and Nathan M. Newmark. The tests were conducted by the Engineering Experiment Station of the university, in co-operation with the Portland Cement Association.

Scope of Investigation

In the planning of these tests, it was decided to give particular attention to the strength and stability of monolithic concrete walls of various types used in concrete house construction. The investigation was of the nature of a reconnaissance of the field rather than a detailed study. The functions of a wall for a residence may be divided into three classifications: (1) To provide safety; that is, to resist vertical loads, wind pressures, and other incidental forces, and to provide resistance to moisture and weathering as well as to fire. (2) To provide comfort; that is, to furnish heat and sound-insulation, and to prevent percolation and condensation of moisture. (3) To be convenient and economical of construction and readily adaptable to architectural requirements. The fact that this report is concerned only with the strength and stability of concrete walls does not, therefore, mean that these are considered to be the only important factors.

There is very little published information available concerning the strength of monolithic concrete walls. Tests have been made on concrete block pilasters, and on the stability and strength of walls of concrete masonry units.*

There are reported herein results of tests on panels of single and double walls of various thickness, made of dry-tamped concrete and constructed in successive courses. Tests were also made on ribbed walls consisting of a slab and vertical ribs constructed as a single unit, and on single walls of the same size and shape as the dry-tamped single walls, all made of poured concrete. Eighteen large and six small wall panels and two ribbed walls were tested with a uniformly-applied axial vertical load. Two ribbed walls were tested with an eccentric load, and seven walls were tested in flexure.

The investigation was carried on at the materials testing laboratory of the University of Illinois, as a regular project of the Engineering Experiment Station, under the administrative direction of Dean M. L. Enger, Director of the Station, and Prof. F. B. Seely, Head of the Department of Theoretical and Applied Mechanics. The Portland Cement Association was represented by an Advisory Committee consisting of Frank T. Sheets, consulting engineer, and R. E. Copeland.

The Arro-Tie Company, of Kansas City, Missouri, furnished the wall ties used in the construction of the ribbed walls and the solid poured walls.

Construction of Walls

It was the primary purpose of these tests to furnish information on the behavior under load of wall panels of sufficient size to represent story-height building construction. Therefore, wall panels 6 ft. long and 9 ft. high were chosen. Several small wall panels 32 in. long and 48 in. high were used also to determine whether or not they could be established as representative test specimens.

To provide a rigid base on which the walls could be built, transported, and tested, reinforced concrete pallets were used. These were 5¾ in. thick, of sufficient area to support the wall, and were concreted on a plane machined surface, so that no bedding was required when pallet and wall were placed in the testing machine. The pallet was stiff enough to prevent appreciable deflection during the fabrication of the wall. Preparatory to building a wall the pallets were placed on two carefully-leveled steel rails and the framework and guides for the sliding forms were built up on the pallets and carefully plumbed. This insured that the completed wall would be plumb and normal to the plane of the base. The walls were anchored to the pallets by ½ in. steel dowel bars 15 in. long, spaced about one foot apart.

Three different mixes of dry-tamped concrete and two mixes of poured concrete were used in the construction of the walls. The dry-tamped mixes were designed to give medium, high, and low-strength concretes. The poured concrete was represented by two different mixes. One was designed to give a medium-strength concrete of sufficient workability to be placed with only a normal amount of spading and no mechanical vibration in the thin reinforced ribbed walls. The other was designed to represent an easily-workable concrete of the same strength as the dry-tamped concrete of medium strength.

Conclusions

The results of the tests may be summarized as follows:

(1) The compressive strength of all axially-loaded walls varied from 1,530 to 4,380 lb. per sq. in. of loaded wall. The wall strength was affected to a slight extent by the type of wall, whether single, double, or ribbed, and to a very great extent by the strength of the concrete composing the wall.

(2) The compressive strength of all axially-loaded walls, large and small, was more than 55 per cent of the strength of the concrete control cylinders, and averaged about 78 per cent of the cylinder strength. Only the 6-in. single walls had a strength equal to the control cylinder strength, although two 4-in. walls approached the cylinder strength very closely.

(3) None of the double walls was as strong relatively as the thickest solid walls, considering that only one of the double walls was loaded. The strongest double walls averaged about 82 to 84 per cent of the cylinder strength. There was apparently some weakening effect due to the manner of placing of the ties. The double 3-in. walls were distinctly the weakest walls tested, in comparison

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*J. R. Shank and H. D. Foster, "Strength of Concrete Block Pilasters under Varied Eccentric Loading," Bulletin No. 60, Eng. Exp. Sta., Ohio State University, 1931.

C. A. Menzel, "Tests of the Fire Resistance and Stability of Walls of Concrete Masonry Units," Proc. A.S.T.M., Vol. 31, Part II, p. 607, 1931.

F. E. Richart, P. M. Woodworth, and R. B. B. Moorman, "Tests of the Stability of Concrete Masonry Walls," Proc. A.S.T.M., Vol. 31, Part II, p. 687, 1931.

F. E. Richart, "The Structural Performance of Concrete Masonry Walls," Jour. Am. Conc. Inst., Vol. 3, No. 6, p. 363, February, 1932.

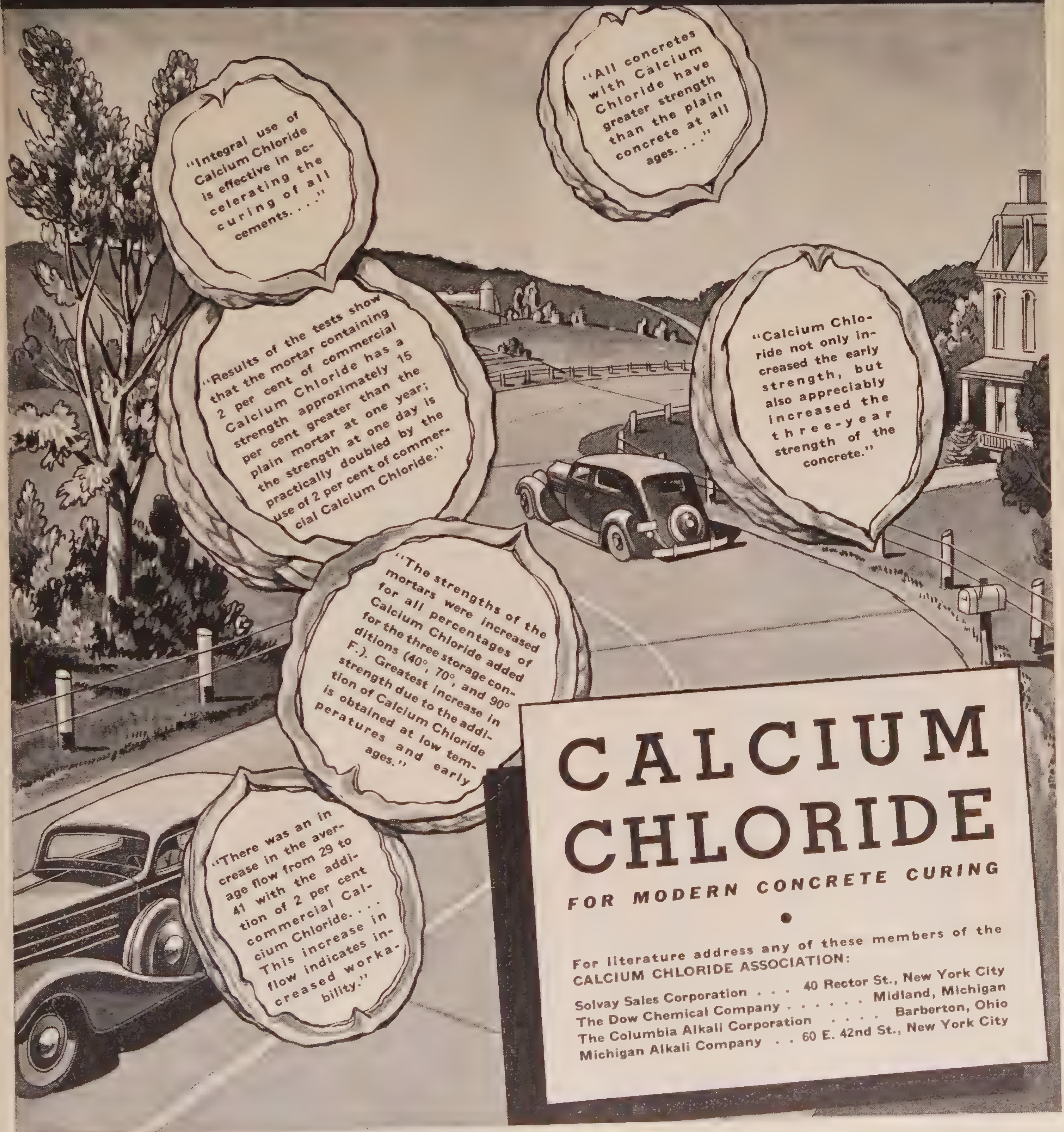
F. E. Richart, R. B. B. Moorman, and P. M. Woodworth, "Strength and Stability of Concrete Masonry Walls," Bulletin No. 251, Eng. Exp. Sta., University of Illinois, 1932.

THE FACTS IN *Nutshells*

from the National Bureau of Standards' Report—"Effect of Calcium Chloride on Portland Cements and Concretes"

CEMENTS: Standard Portland, White Portland, High Early Strength, and Experimental cements—75 in all—covering every possible composition for Portland Cement.

CALCIUM CHLORIDE: Standard commercial product complying with the A.S.T.M. Standard Specifications D98-34.



"Integral use of Calcium Chloride is effective in accelerating the curing of all cements. . . ."

"All concretes with Calcium Chloride have greater strength than the plain concrete at all ages. . . ."

"Results of the tests show that the mortar containing 2 per cent of commercial Calcium Chloride has a strength approximately 15 per cent greater than the plain mortar at one year; the strength at one day is practically doubled by the use of 2 per cent of commercial Calcium Chloride."

"Calcium Chloride not only increased the early strength, but also appreciably increased the three-year strength of the concrete."

"The strengths of the mortars were increased for all percentages of Calcium Chloride added for the three storage conditions (40°, 70°, and 90° F.). Greatest increase in strength due to the addition of Calcium Chloride is obtained at low temperatures and early ages."

"There was an increase in the average flow from 29 to 41 with the addition of 2 per cent commercial Calcium Chloride. . . . This increase in flow indicates increased workability."

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to the cylinder strengths.

(4) From the small number of tests no definite conclusion as to the relative strength of large and small walls may be drawn. Apparently the large walls developed about the same relative strength as the small walls of the same thickness.

(5) The modulus of elasticity of the concrete in the walls was in general about the same as has been observed previously for concrete of the same strength. The modulus varied from 2,400,000 lb. per sq. in. to about 6,000,000 lb. per sq. in. for concrete strengths of 1,730 to 5,850 lb. per sq. in.

(6) The flexural strength of the dry-tamped walls was evidently dependent upon the adhesion between courses, and was least where the courses were constructed 12 hours or more apart. Values of modulus of rupture varied from 60 to 130 lb. per sq. in. for these walls.

(7) The flexural strengths of the solid-poured wall and the ribbed walls were not sensibly different from beam strengths of beams of similar section when all the elements involved were evaluated.

(8) Assuming failure in flexure to take place at the maximum moments recorded in the test walls, and further assuming construction joints in the dry-tamped walls at mid-height, the lateral loads that would cause failure of the walls on a 9-ft. story height are as follows: for solid 4-in. walls of dry-tamped concrete, 18 lb. per sq. ft.; for double 4-in. walls of dry-tamped concrete, 72 lb. per sq. ft.; for 4-in. solid-poured walls, 108 lb. per sq. ft.; and for ribbed walls, about 200 lb. per sq. ft.

(9) The eccentrically-loaded ribbed walls were able to carry only 20 to 30 per cent as great a load as the axially-loaded ribbed walls. The eccentricity was very high, almost four-tenths of the total depth of the section. Heavier rib sections might very profitably be used in walls of this kind, as well as special details for minimizing the eccentricity of loading.

Rented When Modernized

(*Continued from page 5*)

about $100,000. By spending this amount, the owners have converted a "white elephant" into a modernized property that brings in an annual rental of $60,000. The property is valued at $1,000,000.

Acknowledgments. — Samuel Hannaford & Sons, of Cincinnati, were the architects on this work. The general contract was awarded to the Ferro Concrete Construction Company, of the same city. The steel sash was fabricated and erected by the Truscon Steel Company, of Youngstown, Ohio.

General Electric Forms Housing Subsidiary

FOR the purpose of co-operating in the encouragement of house-building of all worthy types, the General Electric Company has organized a separate company known as *Houses, Incorporated.* It will be the purpose of this organization to co-operate with others in the development of houses of any type which seems worthy and promising; to conduct research work; and to assist in the management and financing of such enterprises.

Charles E. Wilson, vice-president of the General Electric Company, will be chairman of the board of the new enterprise; Foster Gunnison, who has been associated with *Houses, Incorporated,* since its inception, will be president. Offices will be located in the General Electric Building, 570 Lexington Avenue, New York City.

Coming Conventions

***Oct. 4-5*—New England and New York State Sewage Works Association. Joint Meeting. Schenectady, N. Y.**

***Oct. 14-16*—Public Works Engineering Conference. Joint Meeting of the American Society of Municipal Engineers and International Association of Public Works Officials, Cincinnati, Ohio.**

***Oct. 14-18*—National Safety Council. 24th Annual Safety Congress. Louisville, Kentucky. A. J. R. Curtis, 33 West Grand Avenue, Chicago, Secretary Cement Section.**

***Oct. 15-16*—Institute of Traffic Engineers. Sixth annual. Louisville, Ky.**

***Oct. 16-18*—American Society of Civil Engineers. Fall Meeting. Birmingham, Ala.**

***Dec. 9-12*—American Association of State Highway Officials. Annual. Miami, Fla. W. C. Markham, Exec. Sec., 1222 National Press Bldg., Washington, D. C.**

Standardized Construction in Low-Cost Apartments

STANDARDIZATION in the planning of flats, says the July issue of *Industrial Standardization,* is the chief feature of the R. E. Sassoon House, a five-story block of 20 low-rental flats at Peckham, England, which was opened recently by Sir Samuel Hoare.

The building is of reinforced concrete construction, and the walls are lined internally with compressed cork. Each flat has a large balcony to accommodate at least two children's beds.

The kitchen is a standardized unit, and this principle is adopted throughout the scheme, with a consequent standardization of all other rooms.

Water-Saturated Mat Covering Cures Pavement Concrete

(Extract from paper by V. L. Glover, in Proceedings of the Twenty-First Annual Road School, held at Purdue University)

RECENTLY one section of pavement was cured in Illinois by means of a saturated mat covering protected by rubberized cloth. This type of mat contains numerous cells for the retention of water, while the fibers from which it is made are in themselves nonabsorbent. Beam specimens were cured in both moist sand and under the cover.

The mat was left in place for three days, and when removed it contained a considerable amount of the original moisture. Upon removal of the mat, the beam specimens which had been cured under it were placed along the edge of the pavement and banked with earth, only one surface of the specimen being exposed. The slab, being a continuous mass, was cured at least as satisfactorily as the beams placed along its edge.

These test beams showed an average strength of about 94 per cent of that obtained from the beams cured in moist sand. If the mat had been left in place more than three days, still better results should have been obtained. Temperature measurements under the mat showed that it possessed some protective properties which might be used to advantage in late fall construction, although this was not investigated sufficiently to make a definite statement.

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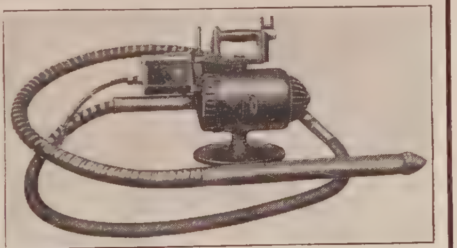

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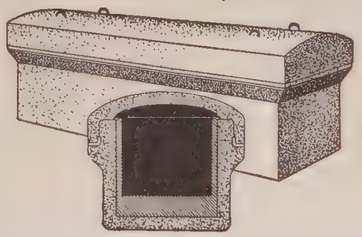

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HOW TO DO IT

Questions and Answers
Consultation and Comment

A department devoted to the solution of problems encountered in concrete work. Readers are welcome to add to or improve upon the suggestions printed and to submit their views for possible publication.

Placing Roofing Tile on Pitched Concrete Slab

How may roofing tile or shingles be fastened to a pitched roof consisting of a thin reinforced concrete or gunite slab supported on steel roof trusses?—E. R. F., Illinois.

One method consists in providing the usual roofing strips by bolting them to metal inserts set in place before concreting, and embedded in the concrete or gun work.

A second method was that employed by Barber and Kingsbury, Los Angeles architects, in the construction of several churches of monolithic concrete. These buildings have steeply-pitched roof slabs of reinforced concrete supported on steel roof trusses. The roof covering, of variegated slate, was laid at random on a 2½-in. coating of *nailcrete*, which had been shot on to the roof slab by a pressure air-gun.

Watertight Concrete for Burial Vaults

I am manufacturing concrete burial vaults and I am particularly interested in making the concrete watertight in itself, rather than having to depend on surface coatings. Can you refer me to literature on this subject?—G. R. A., New York.

An excellent book on this subject is the well-known manual on *Design and Control of Concrete Mixtures,* published by the Portland Cement Association. A request written on your business stationary will bring you a copy without charge.

You will also find useful information on the subject of dense, watertight concrete in the standard specifications for manufacturing concrete burial vaults issued by the American Concrete Institute, 7400 Second Boulevard, Detroit, Michigan. Copies of this specification may be obtained from that organization at 10 cents each.

It should not be forgotten, however, that integral admixtures now on the market have definitely beneficial effects on the density and watertightness of concrete; and that many commercial waterproofers applied to the surface of concrete have been proved effective. The relative value of these surface waterproofers is discussed in an article beginning on page 24 of the July (1935) issue of CONCRETE.

Is Coal Harmful to Concrete?

Our concrete coal silos, now in service about 14 years, show signs of disintegration at several places on the inner surface. No special treatment was applied to these surfaces at the time the silos were built. Do you know of any similar cases, and what can be done to check the disintegration?—C. D. H., Pennsylvania.

Concrete coal-storage silos have been known to suffer disintegration from the action of *wet coal,* more particularly in cases where the coal had a high content of pyrites and marcasite, according to Lea and Desch, in *The Chemistry of Cement and Concrete.*

It is believed that the oxidation of these sulfides (pyrites and marcasite) in the presence of the moisture in the coal results in the formation of free sulfuric acid and iron sulfates. Severe cases have been known where the concrete has disintegrated to a depth of 2 in., while in other cases concrete coal-storage silos have lasted 30 years without trouble.

A lining of aluminous cement mortar has been found effective in reducing the destructive action. If only small patches are affected, the mortar coating may be applied by hand; but to be most effective, such a lining should be applied by means of a compressed air-driven gun.

Molds for Precast Concrete Floor Joists

Will you kindly give me the names and addresses of manufacturers of molds for making precast reinforced concrete floor joists?—D. T. I., Colorado.

At least one company makes complete molds for the manufacture of precast reinforced concrete floor joists. Another company makes a part of the equipment, but not the complete outfit. The names and addresses of these companies are being forwarded to you.

Preventing Action of Sal Soda

I have a problem with a concrete floor I installed a year ago, the floor being subjected to the action of sal soda, which is mixed on it. We installed this floor with the very best of concrete, with a 1-in. hard-troweled mortar topping. No admixtures were used.

The floor is placed directly on the ground, and we now find that a few cracks are forming. The sal soda has not made much headway, presumably because of the hard-troweled surface; but it runs into the cracks and works back, and it is likely to cause trouble.

Can you suggest a suitable material with which to fill these cracks, and a good treatment for a newly-placed concrete floor in a location of this kind?—J. E. B., Colorado.

The cracks may be filled with a bituminous material, as shown in the tabulation on page 18 of the January (1935) issue of CONCRETE. However, proprietary materials prepared especially for repair of cracks in concrete, can be obtained through dealers.

For the surfacing of a newly-placed concrete floor which will be in contact with sal soda (sodium carbonate, or washing soda), suggested treatments—in CONCRETE, January, 1935, page 18—are applications of fluo-silicate, sodium silicate, or linseed oil. When sodium silicate is used, it is applied in a 20 per cent solution in two or more coats 24 hours apart. Ordinarily the sodium silicate requires considerable time to dry before the floor can be used. Commercial sodium silicate varies in strength from 30 to 40 per cent solution. It is quite viscous and requires thinning with water before it will penetrate the floor. It has been found satisfactory to dilute each gallon of the silicate with three gallons of water. Each gallon of the resulting solution will cover approximately 200 sq. ft. of floor surface. The floor should be thoroughly cleaned of all foreign matter, and should be dry before the first application of the solution.

BOOKS On Concrete

List No. 2—Design and Construction, Concrete Making, Cement Manufacture

(Prices quoted are for cash in advance, and include postage)

DESIGN AND CONSTRUCTION OF FORM WORK FOR CONCRETE STRUCTURES. By A. E. Wynn. 320 pages, 219 ills., 12 folded inserts and 11 design tables. Cloth bound, stamped title in gold. Price **$6.00**

"Wynn's Book" is a phrase commonly known to engineers, designers, and foremen, and is heard wherever concrete construction is under way. This book covers every phase of forms for concrete construction, and is fully supplemented with many illustrations, tables and drawings and printed on a superior grade of enameled paper.

CONCRETE CONSTRUCTION MADE EASY. By Leslie Turner and Albert Lakeman. 113 pages, 65 illustrations, 16 tables. Cloth bound. Price **$2.00**

A practical book that solves problems in the design and erection of any type of concrete structure. Full designs with tables and all necessary information for building of foundations, walls, columns, floors, roofs, staircases, beams, water tanks, retaining walls, lintels, formwork, saw-tooth roofs, etc. Written clearly and plainly.

BASIC PRINCIPLES OF CONCRETE MAKING. By Franklin R. McMillan, Director of Research, Portland Cement Association. Ninety-nine pages, 6x9½, 32 illustrations and tables. Price **$2.00**

The author has culled the essentials out of a mass of scientific data on this subject and presents them with force and directness in this book. He shows the effects of quality of material, of proportioning, mixing, working and curing on the finished concrete.

The importance of variable mixes; tests for permeability; how to obtain strength, durability and watertightness; effective ratios; importance of proper construction methods—these and many other vital topics are discussed fully and authoritatively.

GENERAL ENGINEERING HANDBOOK. By Charles Edward O'Rourke and 29 associates. Flexible cover; 921 pages, 5 by 8 in., numerous tables, diagrams, and illustrations. Price **$4.00**

A great amount of fundamental engineering data in usable form, 31 separate sections dealing with as many specific branches of engineering. Of particular interest to engineers who specialize in the use of concrete as a structural material are sections devoted to "Highways," by Thomas R. Agg; "Reinforced Concrete Structures," and "Stresses in Framed Structures," by Charles Edward O'Rourke; "Engineering Materials," by Herbert H. Scofield; "Foundations," by Roland P. Davis; and "Mechanics," by Alfred P. Poorman.

REINFORCED CONCRETE CONSTRUCTION. By George A. Hool, Professor of Structural Engineering, University of Wisconsin.

Vol. I—Fundamental Principles. Third Edition. 380 pages, 6x9, 139 illustrations, 18 tables, 28 diagrams $3.50

Vol. II—Retaining Walls and Buildings. Second Edition. 700 pages, 6x9, illustrated........ $6.00

Vol. III—Bridges and Culverts, 688 pages, 6x9, over 600 illustrations, 41 plates........ $6.00

ESTIMATING AND COST KEEPING FOR CONCRETE STRUCTURES. By A. E. Wynn. Published in 1930; 272 pages, 92 illustrations, 2 folders. Price **$5.00**

The author of this book has had a wide experience in contracting for all kinds of concrete structures, and in this volume he publishes his own simple methods of estimating, cost-keeping and book-keeping. Reproductions are given of all blank forms required.

CONCRETE ENGINEERS' HANDBOOK. By George A. Hool and Nathan C. Johnson, assisted by S. C. Hollister, and with chapters by Harvey Whipple, Adelbert P. Mills, Walter S. Edge, A. G. Hillberg and Leslie H. Allen. 800 pages, 6 x 9. Illus. Flexible binding. Price **$6.00**

A compact reference book, containing tables, formulae and data on plain and reinforced concrete, covering the entire field.

CEMENT CHEMISTRY IN THEORY AND PRACTICE. By Prof. Dr. Hans Kuhl, Director of the Institute for Cement Research, Berlin. Translated into English by J. W. Christelow, B.Sc. 64 pages, 6 by 9, cloth cover. Illustrated with a number of halftones and diagrams. Price **$2.50**

An authoritative book on the chemistry of cement, a translation of a series of lectures delivered by Dr. Kuhl in Moscow, at the special **request of the Soviet government.** The author presents the most up-to-date knowledge of the subject in simple language. The result is a concise record of modern research on the manufacture and setting of cement. Chapter headings are: (1.) The Development of Cement Research; (2.) The Theory of Cement Burning; (3.) The Constitution of Portland Cement Clinker; (4.) The Problem of Hardening and Its Significance in Cement Research; (5) The Chemistry of High-Strength Cements; and (6.) The Technical Aspect of High-Strength Cements.

PORTLAND CEMENT. By A. C. Davis, works managing director, Associated Portland Cement Manufacturers, Ltd. Published in 1934. Cloth, 435 pages, 6½ by 9½ in., 262 illustrations, 22 tables. Price **$8.00**

A new book on cement manufacture, covering more especially the present-day British and continental practices. The author discusses and analyzes such important problems as modern manufacturing methods and organization; formation and nature of cement raw materials; factors governing choice of materials and manufacturing processes; advantages of dry and wet processes; raw material and clinker-grinding problems; improving the efficiency of the rotary kiln; methods of coal feed, slurry drying, and kiln control; reactions in burning cement; rotary kiln heat balances; conservation of heat in rotary kilns; advantages of the purchase of electricitv compared with generation at the factory; modern methods of packing and shipping cement; production costs; mineralogy and chemistry of cement.

STANDARD CONSTRUCTION METHODS. By G. Underwood. 408 pages, 330 illustrations. Price **$5.00**

A complete, detailed presentation of actual methods used in practical construction work. A book packed from cover to cover with plans, short-cuts and expedients for construction superintendents and other men upon whom rests the responsibility of getting jobs done quickly and well.

REINFORCED CONCRETE AND MASONRY STRUCTURES. By Hool and Kinne. 722 pages, 6 x 9, illustrated. Price **$6.00**

The work of 14 specialists. This book offers a practical and detailed discussion of every important element entering into the design and construction of concrete and masonry structures. Particularly noteworthy are the very thorough treatments of Reinforced Concrete Buildings, Concrete Forms, Chimneys and Concrete Detailing.

HELPS TO SUCCESSFUL CONTRACTING. By Harry O. Locher. Published in 1934; 222 pages, 5½ by 8 in. Price **$2.00**

An unusual book for contractors, covering every phase of the work from estimating and bidding to cleaning up and moving to the next job. Written by an author with more than 30 years of experience in the contracting business. Every contractor and construction superintendent or foreman should have a copy.

WINTER CONSTRUCTION METHODS. By Charles S. Hill. Cloth, 180 pages, 6 by 9 in., illustrated. Price **$3.00**

This book assembles in one volume the practices found most effective in carrying on concrete construction work in cold weather. Subjects treated in individual chapters include construction of concrete bridges, roads and street pavements in winter; use of special cements in cold weather; heating of materials; handling and placing concrete; protectig concrete in heavy sections; progressive canvas housing for building construction; and use of complete enclosures.

SPECIAL COMBINATION OFFER: $1.50 (or $2.00 for Cement Mill Edition) added to the price of any of the above listed books will entitle you to one years subscription to Concrete or extend your present subscription one year from its present expiration date. Foreign and Canadian subscribers please write for details.

Book Department of CONCRETE, 400 West Madison Street, Chicago, Illinois

New Books and Pamphlets

Tables for Control of Concrete Mixes

Tables for Control of Concrete Mixes by Weight is the title of a booklet published by the Seeger-Aggragraph Company, Mansfield, Ohio.

The booklet contains tables for estimating quantities of ordinary materials, correction for moisture content of aggregates, and tables for estimating quantities of special aggregates such as blast-furnace slag and manufactured light-weight aggregates. The price is 50 cents.

Highway and Grade-Crossing Regulations

Rules and Regulations Covering Highway and Grade-Crossing Work under the Emergency Relief Appropriation Act of 1935, a 32-page pamphlet published by the National Sand and Gravel Association, Munsey Building, Washington, D. C., as Circular 14, should be in the hands of all highway engineers.

This pamphlet assembles under one cover the rules pertaining to highways and grade-separation structures, thus serving as a most convenient time-saver.

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From the University of Illinois

Several valuable bulletins on concrete appear among the recent publications of the Engineering Experiment Station of the University of Illinois. These include—

Bulletin No. 275. Effect of Time Yield in Concrete upon Deformation Stresses in a Reinforced Concrete Arch Bridge; by Wilson and Kluge. Price 40 cents.

Bulletin No. 276. Stress Concentration at Fillets, Holes, and Keyways, as Found by the Plaster-Model Method; by Seely and Dolan. Price 40 cents.

Bulletin No. 277. The Strength of Monolithic Concrete Walls; by Richart and Newmark. Price 40 cents.

Directory of Federal Agencies

Federal Relief and Recovery Agencies is a useful 32-page booklet, 4 by 9 in. in page size, issued under date of July 1, 1935, by the Northwestern National Life Insurance Company, Minneapolis, Minnesota.

The booklet lists 81 different agencies, giving in each case the address of the Washington office and the name of the official in charge.

ORGANIZATIONS

American Association of Engineers, 8 S. Michigan Ave., Chicago, Ill.; M. E. McIver, Secretary.

American Association of State Highway Officials; W. C. Markham, Executive Secretary, 1222-24 National Press Building, Washington, D. C.

American Chemical Society, Mills Building, Washington, D. C.

American Concrete Institute; Harvey Whipple, Secretary, 7400 Second Blvd., Detroit, Mich.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 West Grand Ave., Chicago.

American Institute of Chemical Engineers, Bellevue Court Bldg., Philadelphia, Pa.

American Railway Engineering Association; E. H. Fritch, Secretary, 59 East Van Buren St., Chicago, Ill.

American Road Builders' Association; Chas. Upham, Engineer-Director, National Press Building, Washington, D. C.

American Society of Civil Engineers; Geo. T. Seabury, Secretary, 33 West Thirty-Ninth St., New York City.

American Society for Testing Materials; C. L. Warwick, Secretary-Treasurer, 260 S. Broad St., Philadelphia, Pa.

American Standards Association; P. G. Agnew, Secy.; 29 West 39th St., New York City.

Associated General Contractors of America; E. J. Harding, Managing Director, 222 Munsey Bldg., Washington, D. C.

Building Officials Conference of America; Wm. F. Hurd, Secretary, Room 203, City Hall, Indianapolis, Ind.

Calcium Chloride Association, 4200 Penobscot Bldg., Detroit, Mich. R. A. Giddings, Secy.

Canadian Good Roads Association; George A. McNamee, Secretary, New Birks Building, Montreal, P. Q., Canada.

Cast Stone Institute; C. G. Walker, Asst. Secy., 33 West Grand Ave., Chicago, Ill.

Cement Information Bureau of the Cement Institute; John B. Reynolds, Asst. to Pres.; N. Oliver Wasson, 33 West Grand Avenue, Chicago, Illinois.

Cement Institute; H. C. Lundborg, General Manager, 11 East 44th St., New York City.

Concrete Reinforcing Steel Institute; R. W. Johnson, Secretary, 201 N. Wells St., Chicago, Ill.

Engineering Institute of Canada; R. J. Durley, Gen. Secy., 2050 Mansfield St., Montreal, Quebec.

Highway Research Board; Roy W. Crum, Director, 2101 Constitution Ave., Washington, D. C.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete; F. R. McMillan, Secretary, 33 West Grand Ave., Chicago.

National Board of Fire Underwriters; W. E. Mallalieu, General Manager, 85 John St., New York City.

National Cinder Concrete Products Association; Harry H. Longenecker, Secy., 1600 Arch St., Philadelphia, Pa.

National Concrete Burial Vault Association; J. H. Stuart, Secretary-Treasurer, Bremen, Ohio.

National Concrete Masonry Association; Horace W. Bush, Secretary and Treasurer, 211 Edgemont Place, Teaneck, N. J.

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National Highway Users Conference; Roy F. Britton, Director, National Press Bldg., Washington, D. C.

National Lime Association; Norman G. Hough, Secretary and Manager, 927 Fifteenth St., N. W., Washington, D. C.

National Ready-Mixed Concrete Association; V. P. Ahearn, Secretary, 545 Munsey Bldg., Washington, D. C.

National Sand and Gravel Association; V. P. Ahearn, Executive Secretary, 545 Munsey Bldg., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, Earle Building, Washington, D. C.

National Terrazzo and Mosaic Association; J. M. Fuhrman, Secretary-Treasurer, 524 Brook Street, Louisville, Ky.

New Jersey State Concrete Products Association; Horace W. Bush, President, Lyndhurst, N. J.

Portland Cement Association; Edward J. Mehren, President; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Rail Steel Bar Association; H. P. Bigler, Engineering Secretary; Builders Bldg., 228 N. LaSalle St., Chicago, Ill.

Steel Joist Institute; R. W. Johnson, Secretary, 201 N. Wells St., Chicago.

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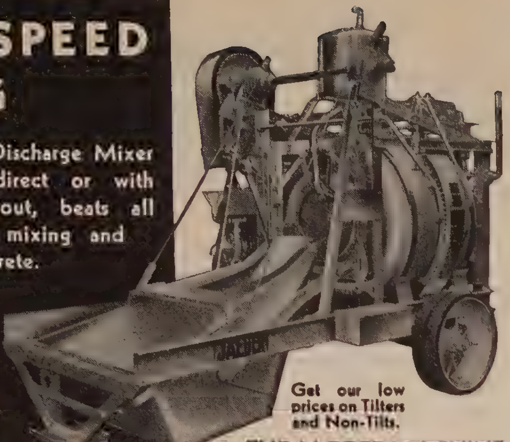

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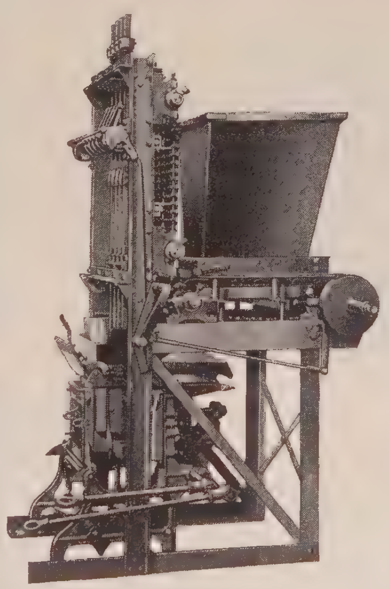

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VEN-ITE is an applied heavy duty controlled floor which, the makers claim, suspends oils, greases and stains, preventing them from penetrating into the body of the floor. The Venite Company, Incorporated of Philadelphia, claim the floors are dense, nonskid, and that they will not dust. They are said to withstand heavy loads, truck wheels, and other conditions encountered in factories and warehouses. Also, they are said to be ideal for toilet rooms, laboratories, corridors, entrances, stair treads, and spaces where a long-wearing, reasonably priced floor is required.

Ven-ite is said to contain aggregates that will not crush or roll out under the most severe traffic conditions.

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A NEW portable rock crusher unit has been developed by the Four Wheel Drive Auto Company, Clintonville, Wis. The new machine consists of a 3-ton FWD truck of the seat-over-motor type equipped with an overhead eccentric type rock crusher mounted on the rear of the frame and driven by the truck motor. The crusher is equipped with continuous bucket feeding and loading elevators of the belt type. This portable crusher is designed to answer the demands of highway officials and contractors for a machine which can be speedily moved from one road building location to another. It is especially adaptable for use along highways being surfaced.

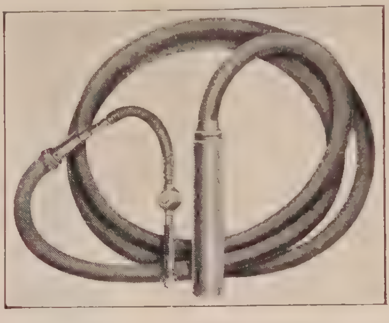
View of FWD Rock Crusher Unit from feeding side

The rock crusher is driven direct from the main shaft of the transmission. With a governed engine speed of 1,200 r.p.m. in direct drive and by means of a four to one reduction in the drive sprockets of the crusher, a crushing speed of 300 r.p.m. can be maintained they say. The rated capacity of the unit at this speed ranges from 50 to 125 tons per day, varying in accordance with the hardness and size of the stone and gravel used.

The four driving wheels of the truck enable it to negotiate the "tough going" encountered in moving to and from location. Its short wheel base gives it the maneuverability necessary to the reaching of stone and gravel supplies located in cramped quarters.

•

C P SHIMMY Spade is an air-powered vibrator for concrete placements. It is said to be a compact, water-tight unit with air motor directly attached to rotary eccentric. High speed, few moving parts, easy handling and low air consumption are features mentioned by the manufacturers, the Chicago Pneumatic Tool Company. There are two sizes. Standard equipment includes 20 ft. of flexible hose, line oiler and hand throttle.



The new C P Shimmy Spade

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THE DAVEY Power Take-off, an invention of Paul H. Davey, Davey Compressor Company, Inc., Kent Ohio, is said to greatly increase the usefulness of the motor truck. It is adaptable for operating truck-mounted machinery—pumps, portable generating plants for lighting systems, arc welders, or driving an air compressor.

The Power Take-off operates from the truck drive shaft by a clutch and is controlled from the driver's cab.

Industrial Literature

AERO-VIBE Screens is the subject of a new and complete Bulletin No. 1474-A, just issued by Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

These vibrating screens, floating in the air suspended by cables and springs, are illustrated in both single and double deck types, together with their multiple V-belt drives. They are stated to be applicable to most any materials sized for commercial purposes, either wet or dry, such as crushed stone and slag, sand and gravel, coal and coke, oyster shells, fertilizers, various ores, oil well drilling mud, and many other materials.

BUTLER bulk cement plants are illustrated and described in Bulletin No. 210 being distributed by Butler Bin Company of Waukesha, Wisconsin.

The use of bulk cement is now an accepted practice in road building and other large construction projects. The savings effected by the use of bulk cement instead of bag cement are: Lower purchase price; lower handling cost; elimination of cleaning cost, handling and returning empty cement sacks, sack loss and money tied up in sacks; quick loading of trucks thus saving in haulage costs; increase in production due to use of "split bag" batches and consequent maximum capacity of mixer drum, and more accurate control of amount of cements in each batch.

The Butler portable, all-steel cement plant is designed especially for road contractors where the time and expense of moving from one set-up to another is a factor to be considered. The plant is designed so that it can be moved from one set-up to another in sections on two motor trucks.

•

TYPE 30 industrial compressors and vacuum pumps, ¼ to 15 h.p., pressures up to 1,000 pounds, is the subject of a new 32-page catalog just issued by Ingersoll-Rand Company, Phillipsburg, N. J.

Compressors are listed with vertical or horizontal receivers, and with electric motor, gasoline engine, or belt drive.

Numerous industrial applications are listed and illustrated. Tables of sizes and capacities are included.

•

WELDING in Construction Work, by A. F. Davis, is the title of an 8-page booklet being distributed by the Lincoln Electric Co., Cleveland, Ohio, manufacturers of arc welding equipment.

Articles in the folder are reprinted from the March, 1935, issue of the Journal of American Welding Society.

•

PROVING by Performance with "Caterpillar" Diesel, is a new folder just issued by Caterpillar Tractor Co., Peoria, Ill.

Testimonials are a feature. Owners' written tributes to their diesel tractors' performance are linked directly to action photographs.

•

INDUSTRIAL Head and Eye Protection (22nd Edition) is a new catalog just published by the Chicago Eye Shield Company, Chicago, Ill., listing their line of industrial head and eye protection equipment, including new and improved products.

Cement Mill Section of
Concrete

Vol. XLIII
No. 9

September
1935

A Phase Rule Study of the System Lime–Potash–Alumina

Methods of Phase Equilibria Employed — Can Predict New Combinations Necessary to Establish Equilibrium When Potash Exists in Presence of Calcium Aluminates

By DR. LORRIN T. BROWNMILLER
Goldschmidt Fellow, 1930-1932
with
DR. LINCOLN T. WORK
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Columbia University, New York

ACKNOWLEDGMENTS. — The authors are deeply grateful to the late Dr. S. A. Goldschmidt, the donor of the Fellowship in Columbia University which Dr. Brownmiller held during the period of the investigation. The authors wish also to express their appreciation to Dr. D. D. Jackson for his interest in this work and his willingness to assist in the arrangements for carrying out the project; and to Dr. R. H. Bogue for his cooperation and for his permission to use the facilities of the Portland Cement Association Laboratory at the National Bureau of Standards for completing some of the experimental work.

ABSTRACT

A part of the system CaO-K_2O-Al_2O_3 has been investigated by the methods of phase equilibria. The binary compound of $K_2O.Al_2O_3$ was found to be stable over a large part of the system. No ternary compounds of the components were found.

The optical properties and X-ray diffraction pattern of $K_2O.Al_2O_3$ were obtained. Detailed thermal measurements were made in the regions of stability of the compounds $3CaO.Al_2O_3$, $5CaO.3Al_2O_3$, $K_2O.Al_2O_3$, $CaO.Al_2O_3$ and CaO.

The results of the studies are significant to those problems of non-metallic mineral chemistry which involve potash in the presence of lime and alumina at high temperatures; specifically to the problems of the ceramic, cement and slag industries.

From these investigations predictions can be made regarding the new combinations which must be effected to establish equilibrium when potash exists in the presence of the calcium aluminates. Those compounds are among the constituents of cements, slags and certain ceramic materials.

The initial melting temperatures of mixtures of lime, potash and alumina, over a range of compositions low in potash, are known from this work.

Finally, a comparison is drawn between the behavior in the system lime-potash-alumina with that in the system lime-soda-alumina.

INTRODUCTION

In non-metallic mineral chemistry lime, silica and alumina occupy predominant roles in consequence to their wide distribution and their extensive utilization in industry. Hence it was logical that the earlier thermal studies for determining the relations of the oxides to one another should be focused on the ternary system CaO-SiO_2-Al_2O_3. The classical work of Rankin and Wright (1) has developed the thermal characteristics and phase relations of that system.

In itself, that work is inadequate for the final solution of the problems encountered in the silicate and allied industries. The influence of other oxides which are usually associated with the lime, alumina and silicate minerals must be determined. But as a consequence of the complications attending a study of the systems of more than three components, the final relations of the oxides to each other are most conveniently determined by an investigation of a series of ternary systems.

An extensive study of oxide systems, especially those involving silica, has been undertaken at the Geophysical Laboratory in Washington (2). Numerous other investigations of ternary oxide systems have been completed. The system CaO-Fe_2O_3-SiO_2 was studied by Hansen and Bogue (3). Al_2O_3 and Fe_2O_3 have been studied together and in combination with CaO (4) and with MgO (5) by Hansen, Brownmiller and Bogue. A ternary system of more complex components, the system $5CaO.3Al_2O_3$-$2CaO.SiO_2$-CaO, was solved by Hansen (6). The system CaO-Na_2O-Al_2O_3 was investigated by Brownmiller and Bogue (7).

The studies reported in this paper have extended the series to include the compound K_2O in combination with CaO and Al_2O_3. The portion of this system chosen for the most detailed investigation is that which is of immediate industrial importance—namely that portion limited to the smaller percentages of potash.

The results of the studies are signifi-

The original printing of the technical data in this treatise appeared in the *American Journal of Science* (1934) under the authorship of Lorrin T. Brownmiller.

cant wherever potash is utilized in the presence of CaO and Al_2O_3 at high temperatures, particularly in the cement and ceramic industries.

In the glass and porcelain industries the alkalies assume extreme importance, for certain properties of the product are largely dependent on the combinations of these oxides. The viscosity of glasses and the devitrification of melts are effected considerably by the presence of alkali in the composition. The production of glazes in ceramics is usually dependent on the use of alkalies. A knowledge of the phase relations in systems involving the alkalies is essential therefore to understand fully the problems encountered in those industries.

In cement manufacture the alkalies may assume a role of great importance. Normally the alkalies are almost completely volatilized in the clinkering zone and the relatively small amounts which remain are almost insignificant. However, the utilization and disposal of precipitator dust from kilns has been an important factor in cement manufacture. Occasionally this dust has been added to the cement slurry. The alkalies are then recirculated through the system so that larger amounts enter the composition of the clinker. Therefore, it becomes of utmost importance to determine the relation of the alkalies to the other constituents. The work reported here indicates the relation of K_2O to two possible constituents of cement clinker, $3CaO.Al_2O_3$ and $5CaO.3Al_2O_3$; from this work the new combinations and the thermal relations of K_2O with those compounds are known.

In slags the principal constituents are minerals of lime, alumina and silica. In addition there are associated with these, minor amounts of many other substances including the alkalies. Accordingly the relation of K_2O to the calcium aluminates is directly involved when detailed deductions concerning the behavior of slags are to be made.

It is recognized that predictions based on the results of studies of individual ternary systems must necessarily be of a general nature until the combined effect of all of the constituents taking part in the reaction is known.

The relations of the more common oxides—CaO, MgO, SiO_2, Al_2O_3, and Fe_2O_3—to each other have been studied in detail. Since the alkalies are widely distributed, the logical step was to determine their effect. Studies on the alkali systems with silica have already been inaugurated at the Geophysical Laboratory. Accordingly, the alkali-aluminate systems were chosen for investigation. Work on the $CaO\text{-}Na_2O\text{-}Al_2O_3$ has already been completed. Since potash and soda are intimately associated, it seemed desirable that the system $CaO\text{-}K_2O\text{-}Al_2O_3$ should be undertaken next in order to contrast and compare the behavior of these two chemically similar oxides in their effect in non-metallic chemistry.

EXPERIMENTAL METHOD

The method of establishing the equilibrium conditions in the ternary system consisted in the preparation of specific compositions over the portion of system to be studied. The heat-treated samples were subsequently examined microscopically and by means of X-rays. The temperature at which the last crystals disappeared on heating, or at which the first crystals were observed on cooling, was taken as the melting temperature of the sample. The general procedure for establishing equilibrium was similar to that used in the study of the system $CaO\text{-}Na_2O\text{-}Al_2O_3$.

In this work, however, special attention had to be paid to the volatility of the potash. In order to insure the accuracy of the final composition upon which temperature measurements were made, the relative proportions of the oxides were controlled by weight. The effect of the volatility of the potash was checked by analysis. And the consistency with which the melting temperatures and the phase relations of a single composition could be rechecked, gave evidence that the amount lost by volatilization was small. These matters are presented in some detail, especially where new problems over those of the soda system were encountered.

The raw materials for the studies were obtained from the Portland Cement Association Fellowship at the Bureau of Standards in Washington. The analyses of these materials are indicated in Table 1.

In the preparation of the samples, base compositions of CaO and Al_2O_3 were weighed in various proportions and thoroughly mixed in a small amount of water. These mixtures were then heated at about 1,350° C. in a platinum resistance furnace. A portion of this base composition was accurately weighed and to it the third component, K_2O was added in the form of potassium oxalate. This compound of potassium was used because it is only slightly deliquescent and, therefore, presented no great difficulties in weighing.

The ternary composition was dry mixed and heated at a temperature of about 1,200° C. A relatively low temperature was used for the first heating because by this procedure less K_2O was lost by volatilization than obtained with higher initial heating temperatures. The samples were then reheated at 1,500° C. All preliminary heating was done in open platinum vessels in the platinum resistance furnace referred to previously. After cooling in a desiccator, the samples were reweighed, and from the increase in weight the amount of K_2O in the mixture was calculated.

Some data on the volatility of K_2O from samples during the heating at 1,500° C. in open platinum vessels are

TABLE 1—PARTIAL ANALYSES OF RAW MATERIALS

Calcium Carbonate*	Per cent	Alumina*	Per cent	Potassium Oxalate**	Per cent
CaO	56.04	Al_2O_3	98.48	Cl	0.005
MgO	.07	SiO_2	.01	Fe	0.001
R_2O (alkali)	.06	Fe_2O_3	.002	Other heavy metals	
R_2O_3	.05	CaO	Nil		None
SiO_2	.01	Cl	Trace	SO_3	0.02
Ignition Loss	43.71	SO_3	Trace		
		Ignition Loss	1.42		

*Analysis by Carlson, Bureau of Standards.
**Analysis by manufacturer.

TABLE 2

Heat Treatment		Sample A	Sample B	Sample C
First heating (1,200° C)	CaO—	46.9%	49.4%	39.8%
	K_2O—	9.0%	4.9%	11.2%
	Al_2O_3—	44.1%	45.7%	49.0%
Second heating (1,500° C)	CaO—	47.9%	50.4%	40.7%
	K_2O—	7.1%	3.0%	9.4%
	Al_2O_3—	45.0%	46.6%	49.9%
Third heating (1,500° C)	CaO—	48.4%	50.6%	40.9%
	K_2O—	6.4%	2.5%	9.1%
	Al_2O_3—	45.2%	46.9%	50.0%

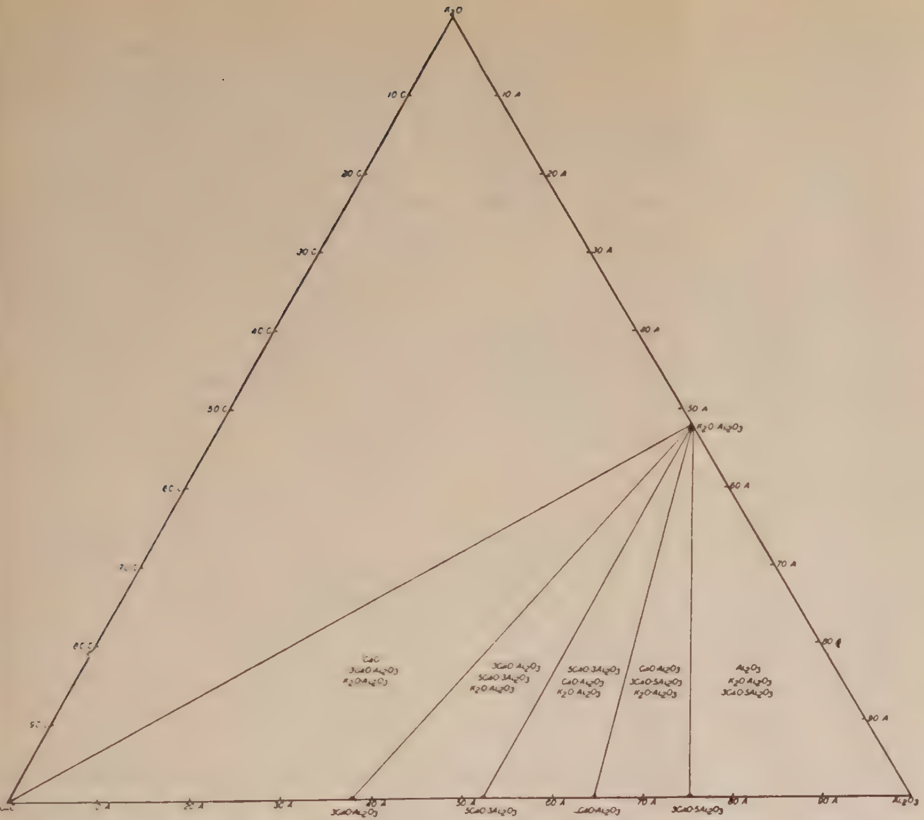

Fig. 1. Diagram showing the final products of crystallization from melt in the ternary system CaO-K_2O-Al_2O_3

given in Table 2. The samples were in the hot zone of the furnace for about thirty minutes. The amount of K_2O lost on the second heating at 1,500° C.—that is, after combination had been effected—was found to be less than 10 per cent of the total K_2O present. Since most of the compositions studied contained less than 10 per cent K_2O, the actual amount lost would be less than 1 per cent K_2O. Furthermore, the samples used for the temperature determinations were always tightly enclosed in platinum foil, and the amount of K_2O lost would be considerably less than the amount lost on heating in the open platinum crucibles. Morgan (8) performed somewhat analogous experiments which revealed losses of K_2O comparable to those reported here from open platinum crucibles.

In Table 3 there is given a comparison of the ratios of CaO:K_2O:Al_2O_3 in a sample heated at 1,500° C., as determined by analysis and by direct weighing.

TABLE 3

Component	Ratio of Oxides by Analysis	Ratio of Oxides by Direct Weighing
CaO	47.7	47.6
K_2O	14.0	13.5
Al_2O_3	38.3	38.9

The details of the method of analysis follow. The sample was completely soluble in hydrochloric acid. Alumina was precipitated and filtered from an ammonical solution containing considerable ammonium chloride. The filtrate was treated with a hot solution of ammonium oxalate. The calcium oxalate precipitate was filtered, washed and ignited over a blast lamp to constant weight.

The filtrate from the calcium oxalate precipitate was carefully evaporated to dryness and heated until all ammonium salts were expelled. The residue was dissolved in a small amount of water and the solution was filtered. After concentrating the solution to a small volume, 5 cc of 3M perchloric acid were added and the solution evaporated until the dense fumes of perchloric acid were given off. The treatment with perchloric acid solution and the subsequent evaporation, until the dense vapors were evolved, was repeated. The solution was then cooled, absolute alcohol added and the potassium perchlorate residue was filtered through a Gooch crucible. The salt was dried at 120° C. for several hours, and weighed.

More than seventy-five different compositions were studied within the region of the diagram indicated in Fig. 2. Fifty of these were in the portion of the system shown in the inset, where the most detailed thermal studies were made.

The samples were finely ground and portions of about 0.3 gram were taken for determining the temperature relations in the system. Temperatures were measured with a platinum-platinum-

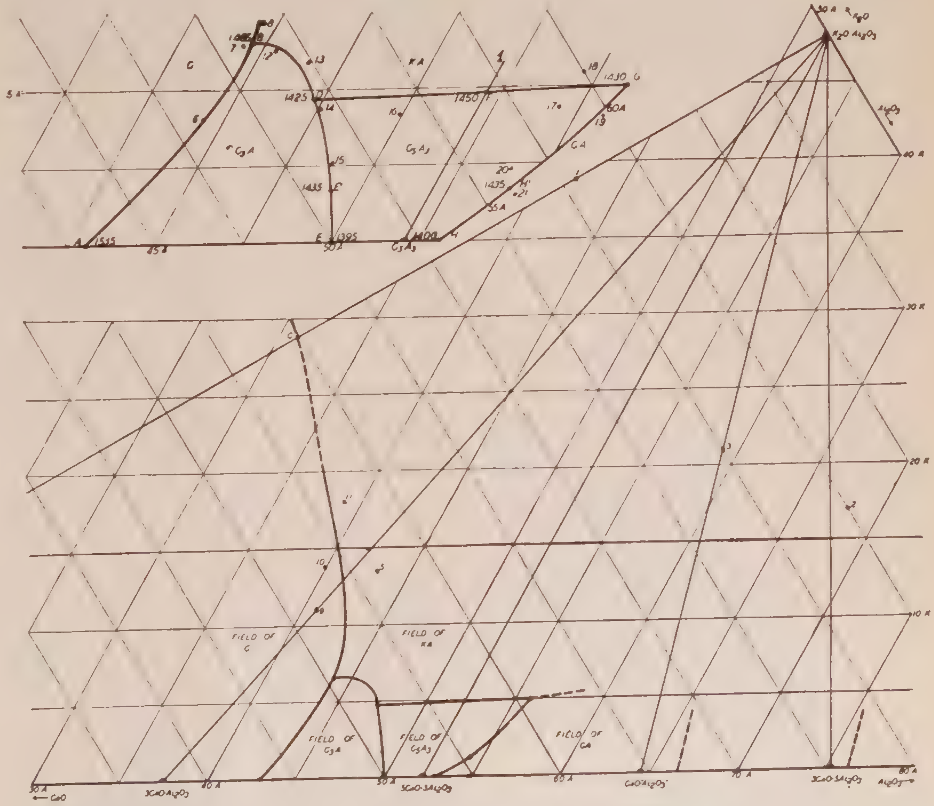

Fig. 2. Diagram showing the fields of primary crystallization and binary systems within the ternary system CaO-K_2O-Al_2O_3

rhodium thermocouple and a Leeds and Northup potentiometer.

Heating curves were not employed for the determination of the melting temperatures, for thermo-elements in contact with melt containing potash are readily attacked. Temperature determinations made by this method would be unreliable. Accordingly, the quenching method was used exclusively for the determination of the temperature relations. In the quenching method a small portion of the sample was enclosed in platinum foil. This charge was suspended by a very fine platinum wire in the hot zone of an upright platinum resistance furnace (9), close to the junction of the thermocouple. The heating element of the furnace was 80 per cent platinum—20 per cent rhodium wire. Temperatures of 1,700° C. could be obtained. The temperature of the furnace was controlled by means of a Robert's regulator (10).

The charges which were used for the final determination of the temperature relations were never held in the hot zone of the furnace for more than thirty minutes; but they were held at the temperature of study for about fifteen or twenty minutes. In establishing the equilibrium conditions in the system the time factor had to be taken into account. Accordingly, charges of the same sample were heated for varying periods; and in general it was found that a charge held at a definite temperature for fifteen to twenty minutes showed the same phases as another charge of the same composition held at the same temperature for longer periods, so that equilibrium was established within that time.

Following such heat treatment a heavy electric current was passed through the fine suspension wire, whereupon it fused and the charge dropped through an opening in the furnace into a reservoir of mercury where it was quenched. By means of petrographic and X-ray examination of the quenched material, the condition of the sample at the temperature of the furnace could be determined. Liquid appeared in the quenched sample as glass, while crystalline material remained unchanged.

Melting temperatures of the samples were determined in the following manner: A charge was heated at an arbitrary temperature and quenched. If no liquid was present at that temperature—that is, if no glass was present in the quenched material—another charge of the same sample was heated at a higher temperature, quenched and examined. The temperature of heating was increased progressively until the sample at one temperature still contained crystalline material, while at a temperature five degrees higher it was completely liquid. The mean value of these two determinations was taken as the melting temperature of the sample.

In order to assure equilibrium conditions in the samples, melting temperatures were also determined on samples cooled from higher temperatures when the deposition of crystals indicated the solidification point. In this way the condition of equilibrium was approached from two directions.

During the period of heating, some potash was undoubtedly lost from the charges. The amount volatized from the samples, which were always tightly wrapped in platinum foil, was so small that changes in the composition could not be detected. Thus, in working with samples lying close to the boundary between the fields of $5CaO.3Al_2O_3$ and $CaO.Al_2O_3$, the phase which crystallized primarily from charges of the same sample heated for periods varying from twenty minutes to one hour, was always $5CaO.3Al_2O_3$. Had the amount of K_2O lost been appreciable, the composition would have been shifted into the field of primary crystallization of $CaO.Al_2O_3$. Such irregularities were never noted along any of the boundary curves, hence evaporation loss was negligible.

Furthermore, thermal data showed that there was no general shift of the compositions of the samples towards the base line CaO-Al_2O_3 due to appreciable loss of K_2O. Temperature determinations along the curve D-G, Fig. 2, indicated a maximum very close to the composition represented by point F. According to the phase rule this maximum must fall on the line connecting the compositions of the two phases crystallizing primarily on either side of the curve D-G; that is, the maximum must fall on the line connecting the compositions, $5CaO.3Al_2O_3$ and $K_2O.Al_2O_3$. If all of the compositions in the system were too low in K_2O—that is, shifted towards the base of the triangle—the direction of the line $5CaO.3Al_2O_3$-F would be towards some other composition than that of $K_2O.Al_2O_3$, which would be in conflict with other evidence.

After continued use of the furnace, an atmosphere of K_2O vapor was created in it, which reacted slowly with the thermocouples. Accordingly, frequent calibration and correction of the elements was necessary. This was done by comparison with a standard thermocouple; and by checking the melting points of the compounds and eutectics in the CaO-Al_2O_3 system.

More than three hundred heat treatments and microscopic examinations were made on the seventy-five compositions selected progressively to define the boundary curves and to obtain the temperature relations in the system. The relevant values are submitted with a critical analysis and interpretation of the results.

The Binary Systems of the Components

The System CaO-K_2O.—No evidence was obtained of the existence of any compounds of CaO and K_2O. At temperatures up to 1,550° C. there was no liquid formation and the samples quenched or cooled from that temperature contained only one phase, CaO, having grains of normal appearance and refractive index. The potash appeared to have been almost completely volatilized; solid solution was not observed.

The System CaO-Al_2O_3.—This system was studied by Rankin and Wright. The detailed relations in the system are given in their paper: "The Ternary System CaO-Al_2O_3-SiO_2" (1).

They found four compounds of the components: $3CaO.Al_2O_3$ which dissociates into CaO and liquid at 1,535° ± 2° C.; $5CaO.3Al_2O_3$, which melts at 1,455° ± 5° C.; $CaO.Al_2O_3$, which melts at 1,600° ± 5° C.; and $3CaO.5Al_2O_3$, which melts at 1,720° ± 10° C. $3CaO.Al_2O_3$ does not form a eutectic with CaO, but the composition CaO 57, Al_2O_3 43 is the quadruple point at which the two compounds are stable in contact with liquid and vapor at 1,535° ± 2° C. $3CaO.Al_2O_3$ forms a eutectic with $5CaO.3Al_2O_3$ having a composition CaO 50, Al_2O_3 50, which melts at 1,395° ± 5° C. $5CaO.3Al_2O_3$ forms a eutectic with $CaO.Al_2O_3$ having a composition CaO 47, Al_2O_3 53, which melts at 1,400° ± 5° C. $CaO.Al_2O_3$ forms a eutectic with $3CaO.5Al_2O_3$, having the composition CaO 33.5, Al_2O_3 66.5, which melts at 1,590° ± 5° C. $3CaO.5Al_2O_3$ forms a eutectic with Al_2O_3 of the composition CaO 24, Al_2O_3 76, which melts at 1,700° ± 10° C.

The System K_2O-Al_2O_3.—The system K_2O-Al_2O_3 was not investigated completely because of the extremely high temperatures, which fall out of the range of the thermocouples. Eight compositions were studied in the system. No melting occurred in these preparations when heated to 1,600° C.; hence the temperatures of melting of the eutectics and compounds could not be determined. Microscopic examinations of the heated preparations showed the presence of two phases, $K_2O.Al_2O_3$ and β-Al_2O_3. When a preparation of the composition $K_2O + Al_2O_3$ was heated to 1,650° C. only one phase persisted; this indicates that no observable dissociation of the compound $K_2O.Al_2O_3$ occurs at that temperature. It appears from these observations that $K_2O.Al_2O_3$ is the only compound of potash and alumina in this system. The compound contains 48.06 per cent K_2O and 51.94 per cent Al_2O_3.

The optical properties and the X-ray diffraction pattern of the compound $K_2O.Al_2O_3$ were measured. It crystallizes in the isometric system. The refractive index of the compound is 1.603 ± .005 for artificial white light. In unmelted samples in the binary system the grains were colorless and rounded; occasionally in melts in the ternary system $K_2O.Al_2O_3$ was found to crystallize as perfect octahedrons.

$K_2O.Al_2O_3$ is extremely hygroscopic and, therefore, it was necessary to grind it in a hot mortar prior to microscopic and X-ray examination. The interplanar spacings of the X-ray diffraction pattern are given in Table 4. The radius of the cassettes was eight inches and the effective wave length of the X-rays was 0.712 A. U.

TABLE 4—INTERPLANAR SPACINGS OF $K_2O.Al_2O_3$

Line No.	d_{hkl}	Intensity
1	3.07	ww
2	2.72	ss
3	2.59	w
4	2.48	w
5	2.395	w
6	2.315	m
7	2.215	w
8	2.000	w
9	1.918	m
10	1.567	s
11	1.488	ww
12	1.348	m
13	1.214	s
14	1.109	w
15	1.025	m
16	.906	w
17	.860	w
18	.820	w
19	.754	w

ss, very strong; s, strong; m, medium; w, weak; ww, very weak.

When samples of Al_2O_3 containing 3.5 per cent K_2O were heated to 1,550° C., corundum and β-Al_2O_3 crystallized. The latter phase was highly bi-refracting and had a platy crystal habit. The individual crystals were too small and intergrown to make accurate index determinations; however, the mean refractive index of masses of these crystals was 1.663. All of these properties correspond to those of other samples of β-Al_2O_3 examined.

THE TERNARY SYSTEM

No ternary compounds of CaO, K_2O and Al_2O_3 were found in equilibrium with liquid in the region of the system studied. The products of final crystallization from melts in the system are shown in Fig. 1.

THE STABILITY FIELDS

The fields of stability of the various compounds in the ternary diagram are shown in Fig. 2.* Each of the components CaO and Al_2O_3, as well as $K_2O.Al_2O_3$, and the binary compounds of CaO and Al_2O_3, are in equilibrium with liquid in the system.

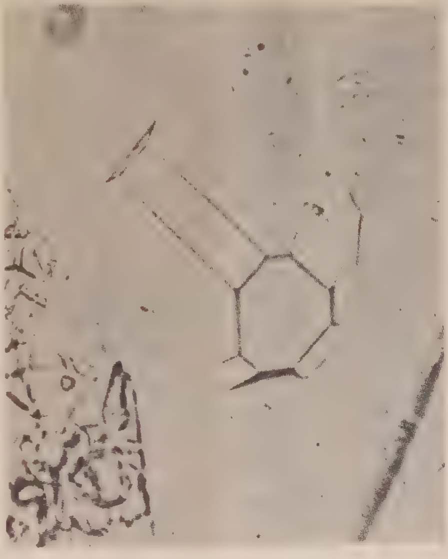

Fig. 3. Photo-micrograph of crystal of $3CaO.Al_2O_3$ in glass. Actual length, 200 microns

The compound $5CaO.3Al_2O_3$ does not crystallize as such in the ternary system, but as a solid solution of K_2O in $5CaO.3Al_2O_3$. The index of refraction of this solid solution varies in accordance with the amount of K_2O dissolved. When the maximum amount of K_2O is present (about 2 per cent) the index of refraction of the phase is 1.593; the refractive index of pure $5CaO.3Al_2O_3$ is 1.608. The X-ray diffraction pattern of the solid solution shows a regular shift in the lines of the pattern as K_2O is progressively taken into solution.

Because of the similarity in optical properties of $K_2O.Al_2O_3$ and $5CaO.3Al_2O_3$ (+ K_2O), some difficulty was encountered in allocating the boundary curve between the fields of primary crystallization of these phases. Both compounds are isotropic and have indices of refraction differing by only 0.01. When $K_2O.Al_2O_3$ crystallizes as the primary phase it forms rounded grains with regular outline; on the other hand, $5CaO.3Al_2O_3$ (+ K_2O) has never been observed to crystallize in this form from melt, but only as irregular grains with jagged edges. This difference in crystallization habit of the phases served as a convenient means for differentiating them. For the final location of the boundary curve, however, samples 13 and 14, Fig. 2, were quenched from temperatures at which only one crystalline phase remained in the glass. These samples were X-rayed and their diffraction patterns were distinctly different; that of sample 13 corresponded to the pattern of $K_2O.Al_2O_3$ and that of sample 14 to $5CaO.3Al_2O_3$ (+ K_2O).

Although the field of primary crystallization of $K_2O.Al_2O_3$ was not completely outlined, samples examined over the greater portion of the system showed that its field of stability adjoins the fields of other compounds in the system. In Table 5 are given the results of an examination of samples which were studied to substantiate this statement.

In the region of primary crystalliza-

TABLE 5—MELTING TEMPERATURES IN THE FIELD OF $K_2O.Al_2O_3$

Sample	Composition CaO	K_2O	Al_2O_3	Heat Treatment		Examination
1	19.0	39.0	42.0	1550	Cooled	KA, Glass
2	15.0	17.0	68.0	1655	Quenched	KA, Glass
				1655	Cooled	KA, C_5A_3
3	20.0	21.0	59.0	1530	Quenched	KA, Glass
				1530	Cooled	KA, CA
4	42.2	6.3	51.5	1455	Quenched	KA, Glass
				1455	Cooled	KA, C_5A_3, Glass
5	43.3	13.5	43.0	1480	Quenched	KA, C_3A. C. Glass
				1490	Quenched	KA, C, Glass

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*For convenience, an abbreviated form of writing the compositions of compounds has been used. Accordingly, for K_2O the symbol "K" is used; for CaO "C"; and for Al_2O_3 "A." Thus KA = $K_2O.Al_2O_3$, C_3A = $3CaO.Al_2O_3$, C = CaO. An enlarged portion of the principal fields is shown separately in the diagram.

tion of $3CaO.Al_2O_3$, that compound crystallized as well-developed polyhedrons, usually with octagonal outline. By careful heat treatment and quenching from a suitable temperature it was possible to isolate extremely large, perfect crystals of $3CaO.Al_2O_3$. Fig. 3 shows a photograph of one of these crystals imbedded in glass. The crystal was approximately 200 microns long; it showed no bi-refringence and appears to be a combination of the cube, octahedron and dodecahedron.

In other regions of the diagram crystal development of the calcium aluminates from melt was extremely good; apparently the viscosity of the melts containing K_2O was favorable for the formation of crystals with well-developed faces.

THE QUINTUPLE POINTS

Two quintuple invariant points were found in the system which represent ternary eutectics; that is, invariant compositions at which three solid phases may co-exist with liquid and vapor. These are points *D* and *G*.

Point *D* is the eutectic for $5CaO.3Al_2O_3$ ($+K_2O$), $3CaO.Al_2O_3$ and $K_2O.Al_2O_3$. It occurs at the composition 48.0 per cent CaO, 4.8 per cent K_2O and 47.2 per cent Al_2O_3. It melts at 1,425° ± 5° C.

Point *G* is the eutectic point for $5CaO.3Al_2O_3$ ($+K_2O$), $CaO.Al_2O_3$ and $K_2O.Al_2O_3$. It occurs at the composition 39 per cent CaO, 5 per cent K_2O and 56 per cent Al_2O_3. It melts at 1,430° ± 5° C.

One quintuple invariant point *B* was found in the system which was not a eutectic; that is, an invariant composition at which three solid phases may exist with liquid and vapor, but which lies outside the triangle formed by the lines joining the compositions of the three solid phases. It occurs at the composition 48.8 per cent CaO, 6.5 per cent K_2O and 44.7 per cent Al_2O_3 and melts at 1,475° ± 5° C. At this point $3CaO.Al_2O_3$, CaO and $K_2O.Al_2O_3$ exist in contact with liquid and vapor.

THE BOUNDARY CURVES

The compositions limiting the field of primary crystallization of CaO are represented in the diagram, Fig. 2, by the curve *A-B-C*. The melting temperatures of the compositions represented by this curve decrease from 1,535° C. at composition *A* to 1,485° C. at composition *B*, which is the quintuple invariant composition of $3CaO.Al_2O_3$, CaO and $K_2O.Al_2O_3$. The dotted portion of this curve, *B-C*, was not accurately located because of the high temperatures involved. However, the experimental data indicate that the melting temperatures are increasing from composition *B* to a maximum on the binary system $CaO\text{-}K_2O.Al_2O_3$ in the vicinity of composition *C*, Fig. 2. The melting relations of the compositions along curve *A-B-C* are given in detail in Table 6.

In Table 7 are given experimental determinations which indicate the limiting compositions separating the field of primary crystallization of $3CaO.Al_2O_3$ from that of $K_2O.Al_2O_3$, represented by curve *B-D*. The data show that the melting temperatures along this part of the curve decrease regularly from 1,485° C. at composition *B* to 1,425° C. at composition *D*, which is the ternary eutectic of $3CaO.Al_2O_3$, $K_2O.Al_2O_3$ and $5CaO.3Al_2O_3$ ($+K_2O$).

In Table 8 are given data which indicate the thermal relations of the compositions separating the fields of primary crystallization of $3CaO.Al_2O_3$ and $5CaO.3Al_2O_3$, curve *D-E*. The melting

TABLE 6—MELTING TEMPERATURES ALONG THE BOUNDARY CURVE SEPARATING THE FIELDS OF CaO AND $K_2O.Al_2O_3$

	Composition			Heat		
Sample	CaO	K_2O	Al_2O_3	Treatment		Examination
		Per cent				
6	52.0	4.0	44.0	1495	Quenched	C_3A, C, Glass
				1505	Quenched	Glass
7	49.5	6.5	44.0	1475	Quenched	C_3A, C, KA, Glass
				1485	Quenched	C, Glass
8	48.0	8.0	44.0	1500	Quenched	C, KA, Glass
				1508	Quenched	KA, Glass
9	48.0	11.0	41.0	1583	Quenched	C, KA, Glass
				1593	Quenched	C, Glass
10	47.0	14.0	39.0	1625	Quenched	C, KA, Glass
				1635	Quenched	C, Glass
11	43.0	18.0	39.0	1665	Quenched	C, KA, Glass

TABLE 7—MELTING TEMPERATURES ALONG THE BOUNDARY SEPARATING THE FIELDS OF $3CaO.Al_2O_3$ AND $K_2O.Al_2O_3$

	Composition			Heat		
Sample	CaO	K_2O	Al_2O_3	Treatment		Examination
		Per cent				
7	49.5	6.5	44.0	1475	Quenched	C_3A, KA, C, Glass
				1485	Quenched	C, Glass
12	48.5	6.4	45.1	1460	Quenched	C_3A, KA, Glass
				1470	Quenched	C_3A Glass
13	47.0	6.0	47.0	1420	Quenched	Not sintered
				1430	Quenched	Melting begun
				1450	Quenched	C_3A, KA, Glass
				1455	Quenched	KA, Glass
14	47.9	4.5	47.6	1420	Quenched	No melting
				1430	Quenched	Melting begun
				1435	Quenched	Glass

TABLE 8—MELTING TEMPERATURES ALONG THE BOUNDARY CURVE SEPARATING THE FIELDS OF $3CaO.Al_2O_3$ AND $5CaO.3Al_2O_3$

	Composition			Heat		
Sample	CaO	K_2O	Al_2O_3	Treatment		Examination
		Per cent				
14	47.9	4.5	47.6	1420	Quenched	No melting
				1430	Quenched	Melting begun
				1435	Quenched	Glass
15	48.7	2.5	48.8	1438	Quenched	C_3A, C_5A_3, Glass
				1447	Quenched	Glass

TABLE 9—MELTING TEMPERATURES ALONG THE BOUNDARY CURVE SEPARATING THE FIELDS OF $5CaO.3Al_2O_3$ AND $K_2O.Al_2O_3$

	Composition			Heat		
Sample	CaO	K_2O	Al_2O_3	Treatment		Examination
		Per cent				
14	47.9	4.5	47.6	1420	Quenched	Not sintered
				1430	Quenched	Melting begun
				1435	Quenched	Glass
16	46.0	4.3	49.7	1420	Quenched	No melting
				1430	Quenched	C_5A_3, Glass
4	42.2	6.3	51.5	1445	Quenched	C_5A_3, KA, Glass
				1455	Quenched	KA, Glass
17	42.0	4.0	54.0	1433	Quenched	C_5A_3, KA, Glass
				1450	Quenched	C_5A_3, Glass
18	40.0	5.5	54.5	1430	Quenched	C_5A_3, KA, Glass
				1435	Quenched	Glass

TABLE 10—MELTING TEMPERATURES ALONG THE BOUNDARY CURVE SEPARATING THE FIELDS OF $5CaO.3Al_2O_3$ AND $CaO.Al_2O_3$

Sample	Composition CaO	K$_2$O Per cent	Al_2O_3	Heat Treatment		Examination
19	40.3	4.0	55.7	1422	Quenched	No melting
				1430	Quenched	Melting begun
				1438	Quenched	CA, Glass
				1445	Quenched	Glass
20	44.0	2.0	54.0	1430	Quenched	C_5A_3, CA, Glass
				1440	Quenched	C_5A_3, Glass
21	44.5	1.0	54.5	1447	Quenched	C_5A_3, CA, Glass
				1455	Quenched	CA, Glass

TABLE 11—COMPOUNDS AND INVARIANT POINTS

	Composition CaO	Al_2O_3 Per cent	K_2O	Melting Point	Authority
Binary Compounds					
C_3A	62.22	37.78		Dissociates to CaO and liquid at 1,535°	Rankin et al.
C_5A_3	47.78	52.22		1,455°	Rankin et al.
CA	35.44	64.56		1,600°	Rankin et al.
C_3A_5	24.78	75.22		1.720°	Rankin et al.
KA		51.94	48.06	Above 1,650°	Brownmiller
Binary eutectics					
C_3A-C_5A_3	50.00	50.00		1,395°	Rankin et al.
C_5A_3-CA	47.00	53.00		1,400°	Rankin et al.
CA-C_3A_5	33.50	66.50		1,590°	Rankin et al.
Quadruple point not a eutectic					
CaO-C_3A	57.00	43.00		1,535°	Rankin et al.
Ternary eutectics					
C_3A-KA-C_5A_3	48.0	47.2	4.8	1,425°	Brownmiller
CA-C_5A_3-KA	39.0	56.0	5.0	1,430°	Brownmiller
Quintuple point not a eutectic					
CaO-C_3A-KA	48.8	44.7	6.5	1,485°	Brownmiller

temperatures of the compositions increase from 1,425° C. at composition *D*, the ternary eutectic, to a maximum of 1,435° C. at composition *E′* along the curve; from composition *E′* the melting temperatures again decrease to 1,395° C., the melting point of the binary eutectic of $3CaO.Al_2O_3$ and $5CaO.3Al_2O_3$. Thus the ternary eutectic *D* melts at a higher temperature than the binary eutectic *E*. This may appear to be a contradiction of the theorem of van Alkemade, from whose deductions "it is known that the temperatures fall along the sides of the triangle towards the ternary eutectic" (11).

These results have been interpreted in the following manner: Pure $5CaO.3Al_2O_3$ does not exist in this ternary system, but takes up K_2O in solid solution. Hence there are only two phases taking part in the equilibrium until the solid solution of K_2O in $5CaO.Al_2O_3$ attains saturation. Therefore, the binary eutectic to be considered in this case is not one of $3CaO.Al_2O_3$ with pure $5CaO.3Al_2O_3$ but one of $3CaO.Al_2O_3$ with $5CaO.3Al_2O_3(+K_2O)$ with a melting point of 1,435° C.; accordingly the temperatures fall from the binary eutectic to the ternary eutectic in agreement with van Alkemade's theorem.

The temperature relations of the compositions separating the fields of primary crystallization of $5CaO.3Al_2O_3$ $(+K_2O)$ and $K_2O.Al_2O_3$, represented by curves *D-G*, are given in Table 9. There is a maximum melting temperature along this curve at composition *F*, the eutectic of $5CaO.3Al_2O_3(+K_2O)$ and $K_2O.Al_2O_3$. This binary eutectic melts at 1,450° C. ± 5° C. From composition *F* the melting temperatures decrease along the curve to 1,430° ± 5° C. at composition *G*, the ternary eutectic of $5CaO.3Al_2O_3(+K_2O)$, $CaO.Al_2O_3$ and $K_2O.Al_2O_3$.

In Table 10 there are given the data showing the melting temperatures of the compositions limiting the fields of primary crystallization of $5CaO.3Al_2O_3$ $(+K_2O)$ and $K_2O.Al_2O_3$, curve *G-H*. The melting temperature of the ternary eutectic *G* is 1,430° ± 5° C., while that of the binary eutectic of $5CaO.3Al_2O_3$ and $CaO.Al_2O_3$, composition *H*, is 1,400° ± 5° C. The relations along this boundary curve are similar to those along *B-E*. That is, a maximum melting point occurs along the curve *G-H* at composition *H′*. *H′* must be considered as the binary eutectic in this case since the solid solution K_2O in $5CaO.3Al_2O_3$ only attains saturation at this composition and, therefore, only two phases take part in the equilibrium. The melting temperature of composition *H′* is 1,435° ± 5° C.

THE BINARY SYSTEMS WITHIN THE TERNARY DIAGRAM

The system CaO-$K_2O.Al_2O_3$.— Since the line joining the compositions of the two compounds lies wholly within the fields of primary crystallization, the compounds form a true binary system with a eutectic in the vicinity of point *C*. Mixtures of the two compounds in varying proportions were heated to 1,700°; CaO and $K_2O.Al_2O_3$ were identified microscopically.

The system $3CaO.Al_2O_3$-$K_2O.Al_2O_3$.—The line connecting the compositions of the two compounds does not lie entirely within the fields of primary crystallization, so that the compounds do not form a true binary system. $3CaO.Al_2O_3$ does not appear on the liquidus of the system.

The system $5CaO.3Al_2O_3$-$K_2O.Al_2O_3$.—The compounds form a true binary system with a eutectic at the percentage composition CaO 42.5, K_2O 5.0, Al_2O_3 52.5. The melting temperature of the eutectic is 1,450° ± 5°.

The system $CaO.Al_2O_3$-$K_2O.Al_2O_3$.—$CaO.Al_2O_3$ and $K_2O.Al_2O_3$ were identified in mixtures in the binary system $CaO.Al_2O_3$-$K_2O.Al_2O_3$ heated to 1,600° ± 5°. The melting temperature of the eutectic was not determined.

The system $3CaO.5Al_2O_3$-$K_2O \cdot Al_2O_3$.—$3CaO.5Al_2O_3$ and $K_2O.Al_2O_3$ were identified in mixtures in the binary system $3CaO.5Al_2O_3$-$K_2O.Al_2O_3$ heated to 1,600° ± 5°. The melting temperature of the eutectic was not determined.

SUMMARY

A portion of the CaO-K_2O-Al_2O_3 system has been investigated and the equilibrium conditions in it have been established. The compound K_2O-Al_2O_3

(*Continued on page 44*)

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EDITORIAL

More Trouble with Imports

The dangers lurking behind reciprocal trade agreements, such as the one concluded with Belgium early in this year, have lost little time in coming out into the open.

Under the agreement negotiated with Belgium by the Secretary of State, the tariff on portland cement was reduced from the very low figure of 22.6 cents a barrel of 376 pounds to the still lower figure of 17 cents a barrel.

In recent months cement imports have been growing, especially from Belgium and Denmark. While most of this dumping has occurred in the New York and Boston areas, moderate quantities of foreign cement have appeared also at New Orleans and other Gulf Coast cities, and so far inland as San Antonio.

With the view of meeting this competition from foreign dumping, cement manufacturers supplying the Brooklyn area have co-operated with dealers in a price-reduction move. This enabled dealers in the four counties of Long Island to reduce the price of cement from $2.18 a barrel to $1.82.

At the time the reciprocal trade agreement with Belgium was negotiated, many American cement manufacturers expressed the belief that foreign producers would make little effort to invade the American market while construction activities were at a low ebb. The concern of American manufacturers was centered mainly on the possibilities of such invasion after the demand for cement had grown active.

Now it appears that this view was too optimistic. The month of May saw a definite increase in cement imports, and the figures have since been growing.

While the actual volume of imports is not large, it is far from being negligible; and once more we see a demonstration of the fact that a very small quantity of imports may create a vast amount of trouble within any industry—especially when that industry has suffered (and is still suffering) from a long period of depression.

Something must be done at the source of the trouble—the trade agreement with Belgium. One possibility is seen in the removal of cement from the list of commodities included in the agreement. Failing in that effort, the industry should make a sustained attempt to obtain an increase in the old basic rate of 6 cents a hundred pounds in the tariff act of 1930.

Until the tariff on cement is raised to a level comparable with the tariff on other basic commodities, the industry will have trouble with imports.

Pioneering in Dry Ice

The Oklahoma Portland Cement Company deserves praise from the entire cement manufacturing industry for its display of the pioneering spirit as expressed in its newly-installed plant for the production of solid carbon dioxide (dry ice) from kiln gases.

This installation, which went into production on August 9, cost a handsome sum of money. The courage of a pioneer was required to authorize the appropriation of the necessary funds.

If the undertaking is even reasonably successful financially, the cement industry will install many similar plants.

Running Them Down

The bar committee for the Eighth (St. Louis) Judicial Circuit has filed a disbarment suit in the State Supreme Court of Missouri against four St. Louis attorneys who, since 1929, have specialized in damage suits claiming injury from the respiratory disease known as silicosis.

Thus the nets are being drawn tighter around the nest of legal sharks who have been working the silicosis racket in Missouri. An editorial on this page, in the May issue, told of the aggressive action of several industrial concerns, who had filed suits against Kansas City and St. Louis attorneys, charging them with barratry and malicious conspiracy in connection with silicosis suits brought against these companies.

The present disbarment proceedings were started after the St. Louis Bar Association made a general investigation of litigation connected with occupational diseases. It was found that the four attorneys now under fire had brought numerous suits against cement manufacturing companies, producers of commercial silica, and lead mining companies, in which the plaintiffs, for the most part, were former employees who were alleged to have contracted silicosis.

The disbarment petition gives the names of 57 individuals who were among the clients of these attorneys, and whose business is said to have been obtained by solicitation. The petition adds that many other silicosis clients were obtained in similar fashion, but their names were not given. The petition charges that these clients were solicited through agreement to pay costs of litigation and medical examinations, and the actual advancement of funds.

The cement manufacturing industry will have reason to breathe a sigh of relief if this gang of racketeers can be run down and cleaned out.

Dry Ice—
A Cement Kiln By-Product

Oklahoma Portland Cement Company Installs First Plant in This Industry—Nature of Solid Carbon Dioxide, and Method of Recovery

By **NORMAN M. STINEMAN**
Editor, *Concrete*, Chicago, Illinois

ANNOUNCEMENT that the Oklahoma Portland Cement Company has installed equipment in its plant at Ada, Oklahoma, for the production of dry ice as a by-product has stirred further interest among cement manufacturers in the possibilities of this newcomer among industrial products.

Characteristics of Dry Ice

Dry ice is the generally accepted name for pure carbon dioxide in solid form. In appearance, in its commercial form, it resembles cakes or cubes of tightly packed and smoothly cut snow; but its temperature is extremely low — 109.6 deg. below zero Fahr.

The product is made by compressing pure carbon dioxide gas into a liquid, then allowing the liquid to evaporate so rapidly that part of it takes the solid form of CO_2 just described.

From Solid to Gaseous Form

This solid form—usually available in 10-in. cubes weighing about 40 lb., but also provided in smaller quantities—is then evaporated for refrigerating and fumigating purposes. In passing back into the gaseous form it does not melt, but sublimes—that is, it passes directly from the solid to the gaseous condition, thus avoiding many difficulties in its utilization that, otherwise, would be encountered. Because of this absence of melting, it is practicable to ship it in light-weight insulated containers made of products such as paper, the insulating value of which would be destroyed if an intermediate liquid condition were to occur.

A cubic foot of dry ice, when passing from the solid to the gaseous state, forms 450 cu. ft. of carbon dioxide gas.

Highly Efficient Cooling Agent

In passing from the solid to the gaseous state, a cubic foot of dry ice absorbs twice as much heat as that absorbed by the melting of a cubic foot of water-ice. Furthermore, the large volume of gas formed is very cold, it is inert, it is a poor conductor of heat, and it is heavier than air. As a consequence, the liberated gas serves as a blanket over the products under refrigeration, thus adding further to the efficiency of dry ice as a cooling agent. At the same time, the gas acts as a preservative of foodstuffs, because of its germicidal properties. By saturating products such as meat and fish with CO_2, it reduces quite materially the rate of growth of many ordinary bacteria.

The actual physical and thermal properties of solid carbon dioxide are as follows:

Specific gravity	1.56
Subliming temperature in carbon dioxide at 760 mm.	—109.6 deg. F.
Latent heat at subliming temperature	246 B.t.u. per lb.
Average specific heat of gas	0.193

The ice-cream industry, as one instance, switched completely from ordinary ice to the new product—for a good reason. Under the old system a 5-gallon cedar tub of ice-cream, packed for distribution by rail or motor truck, required around 85 lb. of ice and 15 lb. of common salt. This 5-gallon unit weighed about 145 lb., but only 30 lb. of it was ice-cream. By using dry ice, this industry can ship its product in light-weight insulated paper containers, and a 5-gallon unit weighs only 40 lb. The saving in transportation charges is obvious, because with the new system a motor truck can carry three times as much ice-cream as it could under the old method.

Also a Fumigant

Aside from its use as a refrigerant, dry ice is used also as a fumigant. Here, again, its germicidal properties come into play. When used as a fumigant it is compressed into a liquid and shipped in cylinders. From these cylinders it may be discharged either in the form of gas or "snow," by adjusting the outlet at the point of discharge. In this way it is used to kill germs, larvae, etc., in grain bins and elevators, in flour mills, rice warehouses, in clothing establishments and upholstered furniture. Its non-flammable and non-explosive character makes it perfectly safe for these uses.

Experiments are also being made in the air-conditioning field, to determine the practicability of dry ice in that industry.

Demand and Price

It would be foolhardy to attempt to estimate the ultimate annual demand for dry ice, especially at this stage of its development, when new uses are constantly being studied and perfected.

Records of production and consumption of dry ice are available from several sources, and are in reasonably close agreement. It is known that actual commercial production was started in 1925, with the meager beginning of 170 tons sold in that year. According to a staff article in the July (1932) issue of *Fortune*, the sales volume grew to 35,000 tons by 1930, 45,000 tons in 1931, and 60,000 tons (estimated) in 1932.

More recent figures have been compiled by J. W. Wizeman, of the chemical division of the U. S. Bureau of Foreign and Domestic Commerce, from various trade papers and trade association reports, and from reports issued by the Bureau of the Census.

The Bureau of the Census reported the *production* of 42,500 tons of solid carbon dioxide (dry ice) in 1931, by 29 reporting plants; and 30,000 tons in 1933, by 26 reporting plants. No census of production was taken for 1930, 1932 and 1934.

The 26 plants that reported a total production of 30,000 tons of solid carbon dioxide (dry ice) in 1933 were quite widely distributed. Of these 26 plants, four were in California; three in Pennsylvania; two each in New York, Ohio, and Texas; and one each in Colorado, Florida, Georgia, Illinois, Indiana, Louisiana, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, Virginia, and Washington.

Among the principal producers of solid carbon dioxide may be mentioned the Dry Ice Corporation, whose head office is in New York; the Michigan Alkali Company, of Detroit; the Mathieson Alkali Works, of New York; and the Liquid Carbonic Corporation, of Chicago.

From the trade association angle, the industry is represented to a certain extent by the Compressed Gas Manufacturers Association, 110 West 40th Street, New York, and the Cardon Dioxide Institute, 75 East 45th Street, also in New York.

The price of the product seems to be stabilized at present, at $70 a ton at the plant, although back in 1932 this price was down to $30 and $40. The present price of $70 a ton is quoted to large users. In smaller quantities the usual price at the present time is 5 cents a pound.

Transporting and Handling

In the meantime, various manufacturers of equipment have developed suitable means for transporting this solid carbon dioxide. At least one car manufacturing company makes motor-truck bodies—one for heavy trucks and one for the lighter types—designed especially for the commercial transportation of dry ice. Another equipment manufacturer produces well-insulated shipping containers of light weight for the convenient handling of this product.

The Manufacturing Process

Several manufacturing processes are available for the production of solid carbon dioxide, or dry ice. An early process tried out at Muscle Shoals involved the use of a water-pressure system. The stack gases were put under high pressure and then scrubbed with water. The water and the gas were then separated, the pressure was released on each—a part of the energy being recovered—and the CO_2 came out in fairly pure form.

In all cases where CO_2 is recovered from by-product sources such as stack gases, kiln gases, coke ovens, and so on, it is necessary, of course, to free the CO_2 from impurities and contaminations, because all trace of taste or odor must be removed from the finished solid carbon dioxide when it is destined to be used with foodstuffs. This was the purpose of the process just mentioned as having been employed at Muscle Shoals.

The Absorption Method

A more recent process, similar to the one just installed by the Oklahoma Portland Cement Company, is known as the chemical absorption method. In this process the kiln gases are pumped into a solution of potassium carbonate or sodium carbonate, or a mixture of the two. In this solution the CO_2 is absorbed, forming a bicarbonate. The solution is then boiled, the carbon dioxide coming off as pure CO_2, and the absorbing chemicals are recovered and used over again. In this process sulfur is often a troublesome side issue.

After the carbon dioxide gas is thus separated in pure form from the kiln gases, it is run through the usual process of being compressed into liquid form, then allowed to evaporate rapidly. In this last-named process a part of it takes the form of solid carbon dioxide, or dry ice. The remainder passes back into the gaseous form, in which form it is recovered and put through the process again.

Watching Results

The entire cement manufacturing industry will be interested in the degree of success attained by the Oklahoma Portland Cement Company in the process of recovering pure CO_2 and compressing it into solid form; and this interest will extend also to the method developed for marketing this by-product, and the price obtained.

The dry-ice plant went into production on August 9, under the personal direction of M. O. Matthews, manager of the cement plant. Production is still on an experimental basis to a certain extent, and is running several tons of dry ice daily. When the plant is running at full capacity and the "bugs" have been eliminated from the installation, it will have a daily output of about 15 tons. The cement company expects to sell the product only at wholesale, mainly for icing trains, motor trucks and buses.

Boric Acid as Flux in Burning Clinker

Bureau of Standards Investigation Approaching Completion

To determine the effect of boric oxide upon the melting points and temperatures of formation of the calcium silicates contained in portland cement, namely, dicalcium silicate and tricalcium silicate, a study of the ternary system $CaO.B_2O_3.SiO_2$ is in progress at the National Bureau of Standards, in Washington. The work is approaching completion.

The binary system $CaO.B_2O_3$ has already been investigated by E. T. Carlson and was reported in the December (1932) *Journal of Research* of the Bureau of Standards in *Research Paper No. 510* under the title of "The System $CaO.B_2O_3$." Copies of *Research Paper No. 510* may be obtained at 5 cents each from the Government Printing Office, Washington, D. C.

In working out the fields of tricalcium silicate ($3CaO.SiO_2$) and of dicalcium silicate ($2CaO.SiO_2$) in the ternary system it was found necessary to extend the investigation to the adjacent fields of 3-2 calcium silicate ($3CaO.2SiO_2$) and of monocalcium silicate ($CaO.SiO_2$) as well as to the field of the calcium borates ($3CaO.B_2O_3$, $2CaO.B_2O_3$, and $CaO.B_2O_3$).

This more complete study is of significance not only with respect to the chemistry of cement, but in relation to the constitution of enamel and ceramic glazes. The portion of the system lower in lime and higher in silica and boric oxide has a bearing upon the constitution of borosilicate glasses.

The tests have developed that dicalcium silicate takes up considerable quantities of boric oxide (added as monocalcium borate) in solid solution by which the alpha-beta inversion temperature is lowered as much as 130 deg. C.

Lime-Potash-Alumina

(*Continued from page 41*)

is the only compound of K_2O which exists in equilibrium with liquid in the system. Accordingly that compound will crystallize from melt in all portions of the diagram which were studied. The optical properties and X-ray diffraction pattern of $K_2O.Al_2O_3$ were obtained. It crystallizes in the isometric system. Its index of fraction is 1.603 ± .005. β-Al_2O_3 was found to crystallize in the K_2O-Al_2O_3 system. Detailed thermal data are included for the regions of stability in the system of $3CaO.Al_2O_3$, $5CaO.3Al_2O_3$ and portions of the fields of $K_2O.Al_2O_3$ and CaO. The compounds and invariant points of the system are set down in Table 11.

(*The next issue will contain the authors' discussion of the industrial significance of the ternary system lime-potash-alumina.—Editor*).

Huron Building Storage Terminal at Saginaw

Company Has Ten Similar Terminals in Great Lakes Region—to Receive Cement in Bulk by Rail and Water

THE Huron Portland Cement Company, on August 13, started construction work at Saginaw, Michigan, on a new terminal for the packing, storage and distribution of cement throughout the Saginaw trade area.

This new terminal is the eleventh of its kind owned by this company, the other ten being located at Duluth, Milwaukee, Muskegon, Alpena, Detroit, Wyandotte, Toledo, Cleveland, Buffalo, and Oswego. The Detroit terminal is shown in the illustration.

The new Saginaw terminal will include six reinforced concrete storage silos, each 26 ft. in diameter and 80 ft. high, having an aggregate capacity of about 50,000 bbl. Provision is being made for the handling of both bulk and sacked cement.

In its location on the west bank of the Saginaw River, the new terminal will have access to rail and water transportation.

It is expected that much of the cement to be distributed from this point will be brought from the manufacturing plant at Alpena, Michigan, in the cement company's own bulk-cement lake steamers, the largest of which has a cargo capacity of 40,000 bbl. Bulk-cement railway transportation will also be utilized for this purpose.

The Burrell Engineering and Construction Company, of Chicago, designed the Saginaw terminal. C. F. Canole is the superintendent in charge of construction.

Huron Portland Cement Company's cement storage and distribution terminal at Detroit, where cement is received in bulk from the company's own lake steamers, and shipped out by rail and motor truck. An additional terminal is now under construction at Saginaw

New Books and Pamphlets

Booklet on Welding

The Linde Air Products Company, 30 East 42nd Street, New York, announces publication of *The Metallurgy of Oxy-Acetylene Welding of Steel.* This booklet, by J. H. Critchett, vice-president, Union Carbide and Carbon Research Laboratories, Inc., is an exceptionally informative discussion of the physical and chemical principles involved in the oxy-acetylene welding of steel. It merits recognition as an authoritative publication on the subject.

Hard-Facing by Welding

HOW TO MAKE IT WEAR LONGER, a 16-page $8\frac{1}{2}$ by 11-in. pamphlet issued by the Lincoln Electric Company, of Cleveland, Ohio, is another industrial publication that can be classed as a valuable book of instructions rather than a catalog.

In its text and in its illustrations will be found the proper working procedure for the following welding problems: (1) Moderate shock-resisting and abrasion-resisting welds; (2) welds to resist rolling or sliding resistance; (3) welds to build up hard cutting edges on metal-working and wood-working tools; and (4) welds to resist impact and severe abrasion.

Single copies may be obtained from the publisher, without charge.

Exposition of Chemical Industries

December Show in New York Expected to Exceed All Previous Exhibits

RECOGNITION of the value of display by American business is indicated by the enthusiastic planning now under way for the 15th Exposition of Chemical Industries, to be held in New York, at the Grand Central Palace, December 2 to 7, 1935.

A high standard of display was attained at the last Chemical Exposition, held in 1933. Results to which this excellence contributed were a large increase in attendance and remarkable sales results to the exhibitors. The experienced exhibitor has in mind the viewpoint of the visitor and arranges graphic and dynamic displays which are comprehensive, but clear. The experienced exhibitor considers how most effectively to convey to the visitor what his product is, what it will do, and where. Design, color, animation, and clear-message simplicity are high points in an exhibitor's booth.

The displays at past Chemical Expositions have given the Exposition a positive personality. They have become an inspiration to visitors attending and have proved an excellent market place for companies exhibiting. Accordingly, with increased interest in display, a yet greater success is anticipated at the 15th Exposition. The conduct of the Exposition and all details of exhibit arrangement and leasing are in charge of the International Exposition Company, Grand Central Palace, New York, and will, as heretofore, be under the personal direction of Charles F. Roth, Manager.

Respiratory Protection Devices

A LIST of devices for respiratory protection approved by the United States Bureau of Mines is included in *Information Circular No. 6845*, single copies of which may be obtained without charge from the Section of Publications, U. S. Bureau of Mines, Washington, D. C.

The 6-page circular, written by W. P. Yant, lists all devices for giving respiratory protection which had official certification of approval by the Bureau on March 15, 1935.

Men and Mills

[News of and for Cement Mill Men]

A clearing-house page for all kinds of news about cement men and cement mills. ℭ Readers in all mills, even though not regular contributors, are invited to send in news notes about personal and plant activities that may be of interest or value to the men in other mills.

Nationally prominent cement company executives met in Denver early in August at a meeting of the trade practices committee of the *National Cement Institute.* The committee considered the perpetuation of former NRA provisions.

Many cement company executives in the western region were invited to attend the meeting.

Among the committee members attending were George F. Coffin of Nazareth, Pa., president of the national association.

Others were G. H. Reiter of Chicago, chairman of the committee; J. F. Neylan of New York; S. W. Storey of Chicago; L. T. Sunderland of Kansas City, Mo., and B. H. Rider of Chicago.

●

Alpha Portland Cement Co., Easton, Pa., reports for the year ended on June 30, net loss of $256,247 after taxes, depreciation, minority interest and other charges, compared with net loss of $282,435 in the preceding year.

This report is subject to annual audit and year end adjustments.

●

The *Ash Grove Lime and Portland Cement Co., Kansas City,* is erecting a two-story machine shop at the Galloway plant.

The structure is being built of concrete. It will house heavy machinery which formerly was exposed to the weather. Day and night shifts are being used in an effort to rush the building to completion.

The Ash Grove Lime and Cement Company has plants at Galloway and Ash Grove, and at Kansas City and Omaha, Neb.

●

Calaveras Cement Company paid a dividend of $1 a share on 7 per cent cumulative preferred stock, on August 12. This was the first dividend since January 15, 1934, and reduces accumulations to $9.50 a share.

●

The *Florida Portland Cement Company,* of Tampa, at the regular summer meeting of the board of directors held in Chattanooga in July, re-elected the following officers:

John L. Senior, Chicago, president and general manager; S. W. Storey, Chicago, vice president; Frank Traynor, Tampa, vice president; Howard Miller, Chicago, secretary and treasurer; A. E. Hjerpe, Chicago, assistant secretary treasurer; Otto Pelham, Tampa, assistant secretary treasurer and B. I. Meyer, Chicago, assistant secretary treasurer.

●

The consolidated profit and loss statement of the *International Cement Corporation* giving the results from operations for the second quarter and six months of 1935 as shown by the fifty-ninth quarterly report, dated July 20, shows improvement.

The quarterly statements, according to Charles L. Hogan, president, are not audited and are based, in certain respects, upon estimates. The estimated net profit for the second quarter amounted to $339,418.26 as compared with $297,075.87 for the second quarter of 1934.

The estimated net profit for the first six months amounted to $455,020.02 as compared with $346,972.32 for the first half of 1934.

●

Lehigh Portland Cement Co. reports for twelve months ending June 30 after provision for taxes, depreciation, depletion and obsolescence net earnings of $682,649. Net income for the twelve months closed June 30, 1934, was $24,020.

●

Operations at the *Limedale* plant (Greencastle, Indiana), of the *Lone Star Cement Company* ceased August 1 until silos which have been filled with cement are again emptied. More than 200 men are employed at the plant.

●

A $2,200,000 *Medusa Portland Cement Co.* serial bond issue is being offered by a Cleveland syndicate.

Bonds are priced at 98.85 and accrued for 3s of near maturity and scaling up at varying rates to par and accrued for 5s, 5¼s and 5½s of longer maturity which are due between 1940 and 1945.

●

The Nebraska Cement Company, Superior, Nebraska, began hauling rock again recently. The railroad track to the quarry has been put in temporary repair. A recent flood washed out the track and grade which caused considerable delay at the plant.

●

North American Cement Corp. reports for 12 months ended June 30, 1935, net loss of $292,225 after taxes, depreciation, depletion, interest and amortization, compared with net loss of $463,632 for the 12 months ended June 30, 1934.

Peerless Cement Corporation, Detroit, is planning a reorganization. William Sayres, special master of Federal Court will take testimony on a reorganization plan on September 4. The plan is proposed by W. C. Russell, receiver for the corporation. The concern petitioned Federal Court July 23 for permission to reorganize under the Federal Bankruptcy Act. Judge Ernest A. O'Brien approved the petition.

●

Pennsylvania-Dixie Cement Corporation and subsidiaries for twelve months ended June 30, show a profit of $1,204,295 before depreciation, depletion and interest, compared with a profit of $568,524 for twelve months to June 30, 1934. After provision for depreciation, depletion and interest, there was net loss of $712,783, against net loss of $1,370,175 for the twelve months ended June 30, 1934.

●

Stephen Sparks, 17 year old son of Superintendent *H. S. Sparks* of the El Paso plant of the *Southwestern Portland Cement Company,* was killed in a premature dynamite explosion while watching blasting operations at the quarry on June 26.

●

As a reward for having no accidents in more than 2,000 working days, the Concrete (Washington) plant of the *Superior Portland Cement Co.* has received a certificate of merit from Gov. Clarence D. Martin, company officials announced on July 22.

●

Signal Mountain Portland Cement Company has announced the distribution of a 2 per cent dividend to preferred stockholders, amounting to around $50,000. The last preferred dividend was paid on February 15.

This payment was authorized by the board of directors at their July meeting.

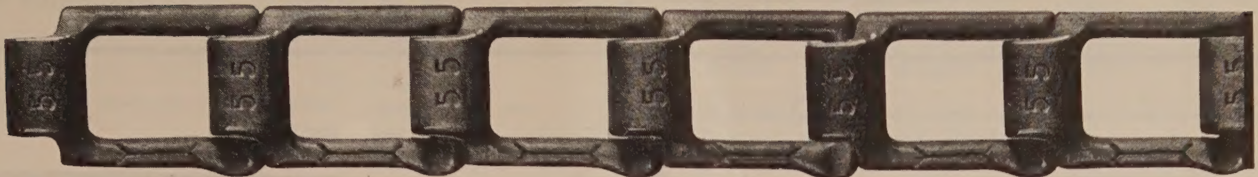
●

Walter A. Wecker, president of the Marquette Cement Manufacturing Company, is having plans drawn for a fifteen-room residence, costing more than $40,000, to be erected on a five-acre tract in Bannockburn, Illinois. Plans have been drawn by Anderson & Ticknor, of Lake Forest, Illinois.

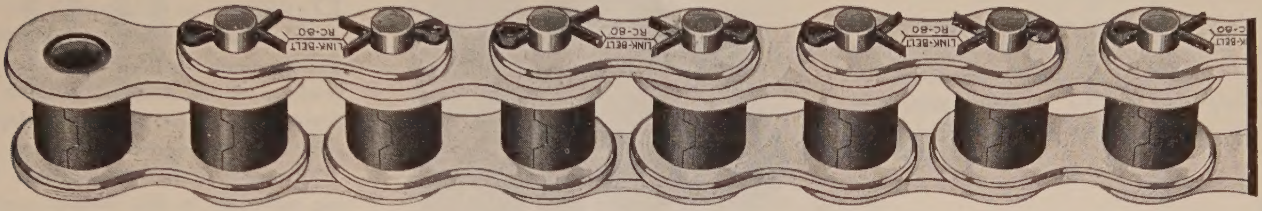
●

George H. Elliott, vice president *Whitehall Cement Manufacturing Co.,* Philadelphia, recently declined to run for mayor of that city.

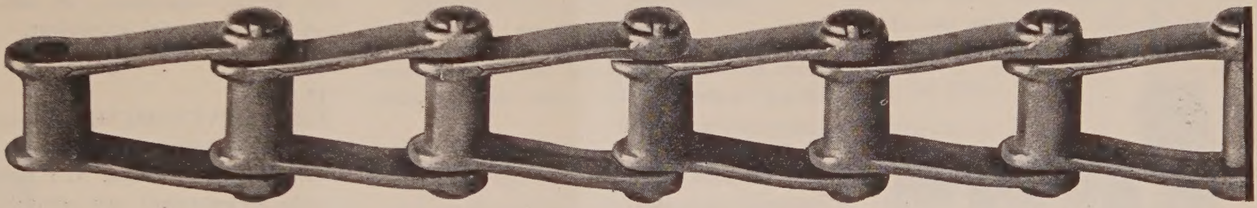
Use Genuine LINK-BELT



CHAINS AND SPROCKETS FOR



CONVEYORS AND DRIVES



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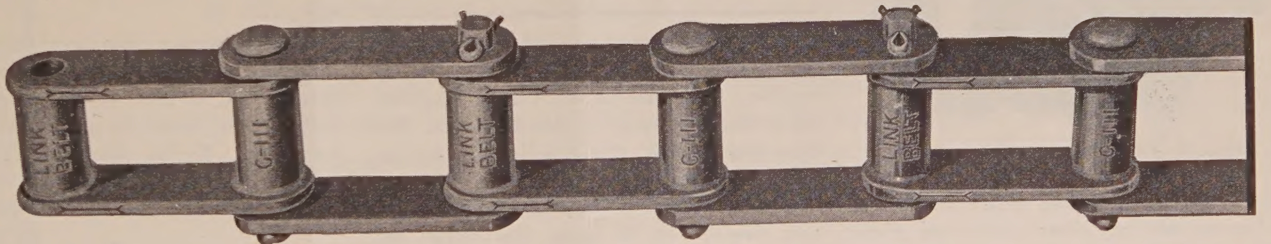
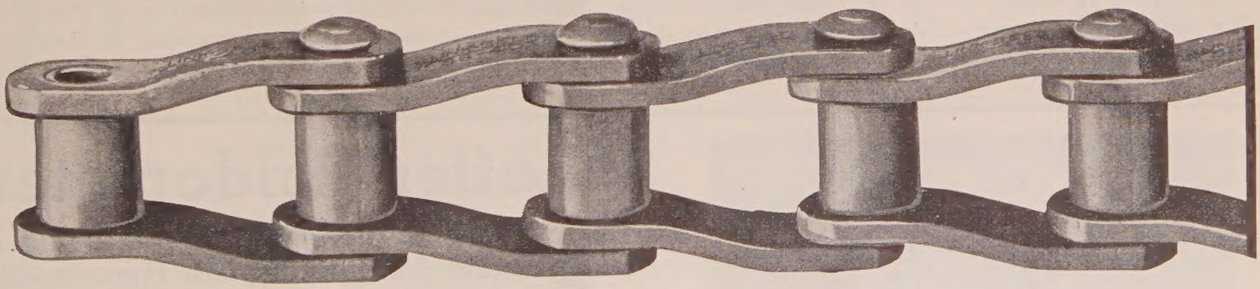


CEMENT MILL SERVICE



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LINK-BELT COMPANY

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CHICAGO PHILADELPHIA INDIANAPOLIS ATLANTA SAN FRANCISCO TORONTO

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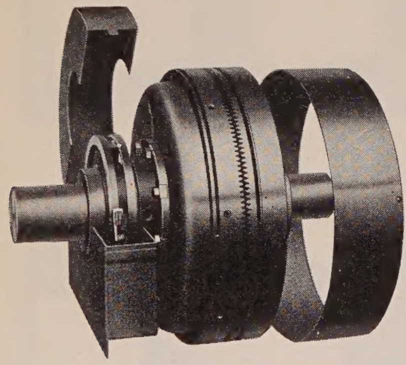
MILL EQUIPMENT

SAN-I-MASK, a new device made by Stephen M. Wagner, Inc., St. Louis, provides protection to eyes, ears, nose and mouth, without preventing speech or causing discomfort. The manufacturers recommend it especially for use where the wearing of respirators is not practicable or desirable.

This new mask is said to be particularly fitted for use in quarry work, machine shop work, for cleaning combustion chambers, for handling coal, and for numerous other uses in and around cement manufacturing plants.

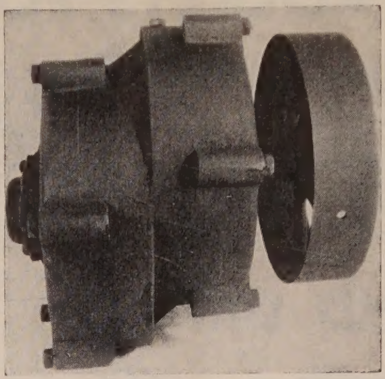
•

MAGNETIC Clutch Coupling, newly patented by Dings Magnetic Separator Co., Milwaukee, insures, they say, positive quick engagement and disengagement, with less than 1½ degrees of slip. This device has already found wide application on hot and cold strip mill secondary screw-down shafts, soaking pit covers and on many other applications where positive engagement and remote control are necessary or desired. They also claim the type SCC clutch transmits unusually high torque, five times that of an ordinary friction type clutch of the same diameter and of either the single disc or multiple disc design.



Magnetic clutch with cover plate removed

SHALER SHAKER is a new development in the mechanics of screening, grading and conveying of materials. The Shaler Shaker, mounted directly on the screen, sieve, shoe, conveyor spout or other device, produces a back-and-forth oscillating movement without being fastened to the frame, floor or other parts of the building.



The Shaler Shaker

The makers, the Ajax Flexible Coupling Co., of Westfield, N. Y., say that vibration is confined altogether to useful work.

Manufacturers' News

B. W. Traylor, prominent crushing and mining engineer, and district manager of the Southern sales office of the Traylor Engineering & Manufacturing Co., Allentown, Pa., died of a heart attack, at Louisville, Ky., on August 14th, aged 64.

Born in Texas a member of one of the pioneer families of the Lone Star State, Mr. Traylor brought to the Traylor Engineering & Manufacturing Co., upon its incorporation, a wealth of experience as a designer, builder and operator of metallurgical plants, which was a valuable aid to the company which he served successively as superintendent, general manager, vice-president and district sales manager.

Industrial Literature

BARRIERS to Industrial Waste is the title of a booklet published by Johns-Manville, describing more than half a hundred insulating products of which they say there is one for every temperature from 400 degrees below zero to 2,500 degrees Fahrenheit.

The table of recommendations for insulating materials in this booklet covers heating and power, ovens and dryers, heat treating furnaces, oil refinery, steel mill, non-ferrous smelting, ceramic, gas making, refrigerating and brewery equipment, hot and cold pipes and other industrial equipment.

•

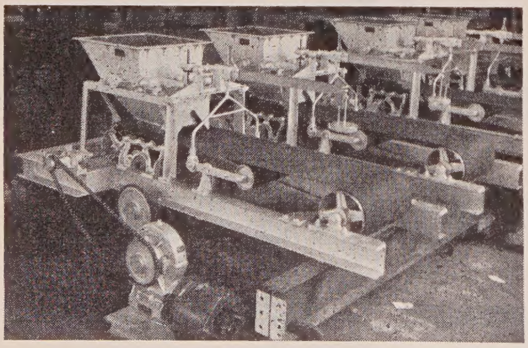
THE CONVEYOMETER, according to Bulletin 10134 being distributed by Richardson Scale Company, Clifton, N. J., guarantees accurate measurement and control as well as continuous feeding of single materials in process, and correct proportioning.

•

THE Bin-Dicator (bin level indicator), an automatic indicator and control of bulk material levels in bins, is described in a new bulletin just issued by the Ripley Manufacturing Co., Wayne, Michigan. The bulletin contains the history, tells how it works, what it does, and who uses the Bin-Dicator.

•

SCREW or Spiral Conveyor Machinery (Section 107 of General Catalog 100) is just being distributed by the Palmer-Bee Co., Detroit, manufacturers of elevating, conveying and power transmitting machinery.



Poidometers for Iola, Kansas, Plant of Lehigh Portland Cement Company

Schaffer Poidometers

are being used for weighing, proportioning and feeding clinker and gypsum into Hercules Mills and Compeb Mills.

They are being used also for weighing and feeding coal to dryers.

Consult our engineers with your problems.

Send for Catalogue No. 5

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